October 27, 2016

Ms. Michelle Kaysen
United States Environmental Protection Agency Region 5
Mail Code LU-9J
77 West Jackson Boulevard
Chicago, Illinois 60604

RE: Final Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report, Hartford Petroleum Release Site, Hartford, Illinois

Ms. Kaysen:

On behalf of Apex Oil Company, Inc. (Apex), 212 Environmental Consulting, LLC (212 Environmental) submitted the draft *Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report, Hartford Petroleum Release Site, Hartford, Illinois* to the United States Environmental Protection Agency (USEPA) and Illinois EPA on July 1, 2016. The USEPA, Illinois EPA, and Tetra Tech (USEPA technical review contractor) provided Apex and 212 Environmental with comments regarding the draft report via correspondence on August 2, 2016. 212 Environmental met with the USEPA, Illinois EPA, and Tetra Tech on August 12, 2016 to discuss the comments and the forthcoming revisions to the report. The revised *Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report, Hartford Petroleum Release Site, Hartford, Illinois* was submitted to the USEPA and Illinois EPA on August 26, 2016. The USEPA comments dated August 2, 2016 and Apex's response to these comments dated August 26, 2016 are included in Attachment A.

The USEPA provided comments regarding the revised *Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report, Hartford Petroleum Release Site, Hartford, Illinois* in correspondence dated October 4, 2016. Apex responded to the additional USEPA comments via correspondence dated October 13, 2016. The USEPA comments dated October 4, 2016 and Apex's response to these comments dated October 13, 2016 are included in Attachment B.

The USEPA submitted follow-up questions via email on October 14, 2016. Apex responded to these additional questions via email dated October 26, 2016. The USEPA provided a final correspondence regarding the revised *Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report, Hartford Petroleum Release Site, Hartford, Illinois* on October 27, 2016. These three correspondences are provided in Attachment C.

Apex has revised Section 5 and Section 6, as well as Figure 21 of the revised *Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report, Hartford Petroleum Release Site, Hartford, Illinois* based on the USEPA, Illinois EPA, and Tetra Tech comments and recommendations. Please find included with this correspondence the following replacement pages for the final *Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report, Hartford Petroleum Release Site, Hartford, Illinois:*

1. Cover and Spine for the Binder
2. Title Page
3. Section 5
4. Section 6
5. Figure 21

These pages should be inserted into and replace the corresponding pages in the revised *Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report, Hartford Petroleum Release Site, Hartford, Illinois* dated August 26, 2016.

Apex and 212 Environmental appreciate your continued engagement with this project. If you have any questions or require any additional information, please contact me at (513) 430-1766.

Sincerely,
212 Environmental Consulting, LLC

Paul Michalski, P.G.

Attachments

cc: James Sanders, Apex Oil Company, Inc.
Tom Miller, Illinois Environmental Protection Agency

ATTACHMENT A

USEPA COMMENTS DATED AUGUST 2, 2016 AND APEX OIL COMPANY, INC. RESPONSE DATED AUGUST 26, 2016

August 26, 2016

Ms. Michelle Kaysen
United States Environmental Protection Agency, Region 5
Mail Code LU-9J
77 West Jackson Boulevard
Chicago, Illinois 60604

RE: Revised Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report, Hartford Petroleum Release Site, Hartford, Illinois

Ms. Kaysen:

On behalf of Apex Oil Company, Inc. (Apex), 212 Environmental Consulting, LLC (212 Environmental) submitted the draft *Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report, Hartford Petroleum Release Site, Hartford, Illinois* to the United States Environmental Protection Agency (USEPA) and Illinois EPA on July 1, 2016. The report summarized the additional testing and evaluation of the geologic, hydrologic, construction, and operational criteria that was performed between January and June 2016, in an effort to optimize recovery of volatile petroleum hydrocarbons beneath Soil Vapor Extraction (SVE) System Effectiveness Zone 6 (Zone 6).

The USEPA, Illinois EPA, and Tetra Tech (USEPA contractor) provided Apex and 212 Environmental with comments regarding the draft report via correspondence on August 2, 2016. 212 Environmental met with the USEPA and Tetra Tech on August 12, 2016 to discuss the comments and the forthcoming revisions to the report. A response to the comments as well as, the revised *Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report, Hartford Petroleum Release Site, Hartford, Illinois*, is provided with this correspondence.

Apex and 212 Environmental appreciate your continued engagement with this project. If you have any questions or require any additional information, please contact me at (513) 430-1766.

Sincerely,
212 Environmental Consulting, LLC

Paul Michalski, P.G.

Attachments

cc: James Sanders, Apex Oil Company, Inc.
Tom Miller, Illinois Environmental Protection Agency

Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
		Section 1.0 Introduction	
1	1.0 Page 1-3 Para 1	Re: "*These wells have not been operable largely due to occlusion of the well screen with groundwater over time. This occurs despite an extensive effort to install stingers within the extraction wells and recover groundwater via total phase extraction (TPE) instead of operating the wells to solely recover vapors, as originally designed*." Without effective dewatering, these extraction wells are too deep to be used.	It is recommended that the report clarify that if significant changes aimed towards improving dewatering are made (e.g., installation of a water treatment system), the wells with the occluded screens could be made operational.
Response to Comment 1	Apex concurs that the HSVE wells with occluded screens could be operational if there were significant changes to the groundwater treatment infrastructure. Such changes would require construction of a system capable of continuous treatment and discharge of water at flow rates one to two orders-of-magnitude higher than the average accumulation rate at the thermal treatment system currently located on the Premcor facility adjacent to the Village of Hartford. However, the results of the enhanced total phase extraction (TPE) test, did not indicate that significantly increasing the groundwater extraction rates from the three vapor recovery wells screened in the Rand stratum and located on North Olive Avenue in Soil Vapor Extraction (SVE) Effectiveness Zone 6 (Zone 6) would result in a significant increase in the mass recovery of volatile petroleum hydrocarbons. The enhanced TPE test was performed during a period of low groundwater elevations in the Rand stratum and in a portion of Zone 6 that contains light non-aqueous phase liquids (LNAPL) and associated elevated concentrations of petroleum and non-petroleum related hydrocarbons in the dissolved and vapor phases.		
2	1.1 Purpose Para 1 Bullet 1	Re: "*Reevaluation of the three dimensional (3D) visualization of the geologic setting underlying Zone 6. A detailed 3D visualization analysis of the lithology described during installation of soil borings was prepared and subsequently compared to the generalized 3D stratigraphic interpretation of the geologic setting. These 3D visualization analyses were compared to determine if there are additional geologic factors that may be affecting efforts to recover volatile hydrocarbons in specific locations in Zone 6*."	The revision of the three-dimensional visualization analysis (3DVA) based on the reinterpretations of the original boring logs should provide the basis for more accurate understanding of site heterogeneity. It is recommended that 3DVA continue to be used to support future evaluations of removal efficiencies of all contaminant phases (LNAPL, dissolved, vapor) from within specific zones and wells, in relation to screened intervals and lithologies.
Response to Comment 2	Apex concurs that the reevaluation of the three dimensional (3D) visualization of the lithology beneath the Hartford Site can, in some cases, provide a more nuanced understanding of site heterogeneities, that may support future evaluations of hydrocarbon mass removal and losses and may serve as a useful tool to communicate site conditions to stakeholders. As indicated in Section 6 (Recommendations) if specific data gaps are identified in the conceptual site model that may be resolved through further evaluation of the detailed 3D visualization analysis of the lithology, then additional modeling may be performed in focused portions of the Hartford Site, similar to the analysis completed for Zone 6.		

Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
Section 2 Background			
3	2.1.2; Table 1	Table 1 presents a summary of the soil vapor extraction wells construction and settings.	It is recommended that the stinger depths be added to this table.
Response to Comment 3	Stinger depths are periodically (as often as semi-weekly) adjusted in response to fluctuations in the groundwater table and as such are continually in a state of flux. Stinger depths and adjustments are provided within Appendix A of the *Semiannual Soil Vapor Extraction (SVE) System Operations, Maintenance, and Monitoring (OMM) Report* .		
4	2.1.2 Soil Vapor Extraction	This section presents a general summary of Zone 6 soil vapor extraction (SVE) operations.	Applied vacuum is an important operational parameter for SVE. It is recommended that a description of the applied vacuum levels measured during the test be added to this section.
Response to Comment 4	This section was intended to provide an overview of SVE operations within Zone 6, specifically to highlight the challenges associated with continuously operating individual extraction wells installed within the Rand stratum and was not intended to provide specifics regarding the day-to-day operation and monitoring of SVE wells across the Hartford Site. Details regarding operating parameters are highly variable due to fluctuations in the groundwater table and are provided within Appendix A of the *Semiannual SVE System OMM Report* .		
Section 3.0 Site Setting			
5	3.1.1 Generalized Stratigraphic Interpretation Page 3-3 Figure 9	Re: "*In addition, a 3D isopach map of the generalized stratigraphy showing the clay, silt, and sand units is included on Figure 9* ."	It is recommended that these 3DVA approaches and outputs continue to be used to evaluate the site and to communicate site conditions to stakeholders, as specified in Comment Numbers 6 and 7. Given the current condition of the site, it may provide additional benefit in the future to apply integrated 3DVA (geology, hydrogeology and contamination [all phases as applicable]) at the strategic and larger-scale evaluation levels as the remedy progresses, and to present the results using this approach to lithologic visualization.
Response to Comment 5	Please refer to the Response to Comment No. 2.		
6	3.1.2 Detailed Lithologic Interpretation Page 3-5 Figures 7 and 8	Re: "*While the detailed lithologic interpretation depicts a more nuanced and discontinuous setting within the upper 40 feet of the subsurface compared to the generalized stratigraphic interpretation, it is not any more accurate in showing the actual geology, as reported within the borings installed via Cone Penetration Testing* ."	Use of Cone Penetrometer Testing data may be beneficial in the future, but should not wholly replace 3DVA of "actual geology" based on USCS Soil Types data. Further, if 3DVA of detailed lithology using numeric value equivalents to represent USCS Soil Types is to be continued, it is recommended that these data equivalents be used to visualize the heterogeneity based on "actual geology" versus emulating the approach of representing geology expressed as the distribution of relative hydraulic conductivity (K_R). The K_R approach, however, may provide greater benefit in the future when remediation is more specifically focused on the distribution, fate and transport of dissolved phase contamination.

Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
Response to Comment 6	Apex concurs that the use of cone penetrometer testing (CPT) data, or similar geophysical data (e.g., electrical conductivity) could be useful to resolve specific data gaps related to the Hartford Site. Apex also agrees that such geophysical data does not replace the use of 3D visualization of the lithologic setting. As discussed in Section 3.1.2 and further described in Appendix A, the USCS soil types were converted to a numerical value based on relative grain size and sorting with the soil types comprised of the smallest grain size (i.e., high plasticity clays, fat clays) assigned a value of 1 and largest grain size (i.e., well graded sands or gravelly sands) assigned a value of 16. During the teleconference between 212 Environmental Consulting, LLC, United States Environmental Protection Agency (USEPA), and Titrates conducted on April 13, 2016, it was agreed that a whole number numeric value would be used to depict the USCS soil types within the revised 3D visualization of the lithology underlying Zone 6. It is likely that the numeric value equivalents used in the revised 3D visualization of the lithology underlying Zone 6 would be consistent with a reinterpretation of the 3D visualization of lithology performed using a distribution of relative hydraulic conductivities for each UCSC Soil Type. It should be noted that the hydraulic conductivity for a given UCSC Soil Type can span several orders of magnitude (http://www.geotechdata.info/parameter/permeability.html).		
7	3.1.2 Detailed Lithologic Interpretation Page 3-5 Figures 7 and 8	Re: "*Although the model provides a better sense of the distribution of glaciofluvial deposits in the shallower portions of the subsurface, detailed analyses using existing lithologic logs and additional soil borings will be necessary when designing new recovery wells at the Hartford Site* ."	It is agreed that the boring logs from any future borings should be used to design wells and screened intervals. However, it is recommended that 3DVA be used as a line of evidence to support the identification of locations for any new borings at the site, as well as to help determine what target depths to drill to.
Response to Comment 7	Please refer to the Response to Comment No. 2.		
Section 4.0 Enhanced Total Phase Extraction Test			
8	4-1 – Methods; Table 7	Depth to water in all extraction wells is at least twice that of the available vacuum lift, which should make the ability to remove water from a well impossible based on the current methods described. It is presumed that there must be some method element(s) missing from the descriptions.	It is recommended that the report clarify the method of water removal used during the test to resolve the review observation. Include details such as stinger height adjustment to initiate and maintain the process and the use of dilution valves to control the process. Clarify whether an airlift method was used, and if so, describe how the method is inherently unstable when it relies on vacuum and is a process that can easily shut down if adequate air flow is unavailable.
Response to Comment 8	It is recognized that vacuum lift for the SVE system at the Hartford Site (with a typical maximum operating vacuum of 100 in-H2O) could not recover groundwater at depths greater than approximately 8 feet below ground surface. Therefore, an airlift method is employed wherein air moving at high velocity entrains water droplets at the air-water interface and conveys them upward into the horizontal conveyance line. The terminal end of each stinger consists of a beveled tip which allows for continued airflow at high velocity and reduces the likelihood of shutting down (i.e., deadheading) while the stinger is incrementally lowered. Using visual and auditory cues from water flowing through the transparent tubing at the stinger head, the field technicians gradually lowers the stinger to a target depth within the vertical well screen, stopping when a steady flow of water is observed within the stinger. While regional groundwater fluctuations have the potential to result in unstable flow conditions, these were not observed during the duration of the enhanced TPE test. It should be noted that the stinger depths are periodically (as often as semi-weekly) adjusted in response to fluctuations in the groundwater table and as such are continually in a state of flux. Stinger depths and adjustments are provided within Appendix A of the *Semiannual SVE OMM Report* . Section 4-1 was revised to include this discussion regarding water withdrawal during the enhanced TPE test.		

Apex Oil Company, Inc. Response to USEPA Comments
Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report
Hartford Petroleum Release Site, Hartford, Illinois

<table>
<tr><th>Comment Number</th><th>Sub-section</th><th>Topics of Discussion</th><th>Recommended Revisions</th></tr>
<tr><td>9</td><td>4-1 – Methods; Table 7</td><td>Water levels in all extraction wells are approximately 1 foot above the bottom of the stinger tubes. It would be impossible to remove water via a stinger under this scenario.</td><td>Please clarify on Table 7 the actual stinger depths versus the liquid/air interface position and provide the rationale for any discrepancies.</td></tr>
<tr><td>Response to Comment 9</td><td colspan="3">As shown on Table 7, water levels within each of the extraction wells used during the Enhanced TPE test are approximately 1 foot below the bottom of the stingers. It is important to understand that fluid level measurements collected within each of the SVE wells are estimated values as the vacuum must either be disrupted or shutdown prior to gauging the fluid level within the operating wells. In the case of the three extraction wells used for the enhanced TPE test, there is a small sample port in each of the well caps that is utilized for fluid level measurements. The cap is removed from the sample port and an interface probe is quickly lowered to air-water interface; however, this process temporarily disrupts the casing vacuum, and likely results in lower measured groundwater elevations than those present under normal casing vacuum during operation of the well. It is assumed that once the system vacuum is reapplied, the groundwater elevation increases such that the air-water interface rebounds to the approximate depth of the tip of the stinger. A footnote has been added to Table 7 and the text in Section 4.1 has been modified to explain the qualitative nature of the fluid level measurements within the operating extraction wells.</td></tr>
<tr><td>10</td><td>4-1 – Methods; Figure 19</td><td>Water removal rates and air flows were measured once per day by temporarily connecting the 40-gallon knock-out tank and a flowmeter to the vacuum header. The majority of the measurements were performed using 5-minute intervals per day for each well. This method would not provide reliable data because the water removal rates and air flows during the majority of operation would differ from those during the short-time measurement intervals. More reliable data would be obtained by using an electrical pump operated by level switches and a flow totalizer to evacuate liquid from the knock-out tank in a continuous flow fashion during the test.</td><td>It is recommended that the report clarify the limitations of data representativeness for water removal rates and air flow measurements obtained during knock-out tank performance testing and that as a result, the water removal rates and totals volumes provided are order-of-magnitude estimates.</td></tr>
</table>

Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
Response to Comment 10	It is agreed that more sophisticated techniques for estimating groundwater extraction rates, such as described within Comment No. 10, may provide more accurate water removal rates. However, the extraction wells used for the enhanced TPE test are located within North Olive Avenue (an active roadway) within the Village of Hartford and as such, long term measurements or continuous measurements would not be safe or practical. In addition to the water removal rates estimated using the in-line knockout tank, water removal rates were also measured within the Main Header transmitting all of the recovered soil vapor and groundwater to the thermal treatment system located on the Premcor facility. Prior to the start of the test, the water removal rate for the entire SVE system was 1,000 gallons per day (gpd) as recorded on February 29, 2016. During the enhanced TPE test the water removal rate increased to between 2,600 and 2,800 gpd. Following the enhanced TPE test, the water removal rate decreased to 1,400 gpd, as recorded on March 14, 2016. Note that towards the end of the test, the river stage increased and precipitation was recorded (a total of 0.3 inches), which would have also resulted in increased water removal rates following completion of the test. Based on the aggregate measurements recorded within the Main Header, it is estimated that the combined water removal rate from the three wells utilized during the enhanced TPE test were between 1,200 to 1,800 gpd. The estimated average groundwater extraction rate for the enhanced TPE test using data collected from each well using the knockout tank was 1,963 gpd, only slightly higher than the maximum that can be estimated using aggregate flowrate measurements from the Main Header. Furthermore, the variability of the daily water removal rates recorded within the individual test wells was relatively low indicating that the measured rates were likely accurate. Based on the close agreement between the individual well and system aggregate measurements (i.e., Main Header), it appears that the flow rates reported during the test are reasonable and are not "order-of-magnitude estimates". The text in Section 4-2 has been modified to include this discussion to provide benchmarks for interpreting the water removal rates.		
11	4-1 - Methods	The report does not mention that electric well pumps were initially used to evacuate water from the test extraction wells. Thus, the total removal volume was unaccounted for.	It is recommended that the report include the volumes of water evacuated from each extraction well using electric well pumps.
Response to Comment 11	Electric pumps were not used to initially remove groundwater from each of the extraction wells prior to performing the enhanced TPE test, rather the existing stinger within each of the wells was used to purge water from the well as described in the Response to Comment No. 8. The text within Section 4.1 as been modified to provide additional detail regarding the process of initially removing groundwater from the extraction wells prior to the start of the enhanced TPE test. The amount of water initially removed using the stinger ranged from 11.2 gallons from well HSVE-060 to 14.2 gallons from well HSVE-059, and is minor compared to the water generated during the enhanced TPE test (approximately 20,000 gallons).		
12	4-1 - Methods	Reliable air flow measurements could not be performed during the majority of the test due to the time elapsed during the use of, or change-out, of unsuitable measurement instrumentation.	It is recommended that the report clarify that reliable air flow measurements could not be performed during the majority of the test due to unsuitable measurement instrumentation used.

Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
Response to Comment 12	It is agreed that the air flow measurements recorded during the first seven days of the enhanced TPE test were not as accurate as measurements collected thereafter due to the high range of the Dwyer gauges (0-100 and 0-50 scfm), as discussed in Section 4-1. During the first four days of the test (March 1 through March 4, 2016) airflow was measured using a Dwyer VFLO venturi flowmeter equipped with a magnehelic gauge that provided a broad range for measuring air flowrate (0-100 scfm) with the lowest scale reading at 20 scfm. A smaller range magnehelic gauge (0-50 scfm) was acquired and used for measurements collected on March 7 and 8. Therefore, it is possible that airflow was occurring between 0 and 20 scfm during the first four days and between 0 and 10 scfm on March 7 and 8th but could not be accurately measured with the magnehelic gauges. However, it is unlikely that the air flowrates recorded between March 1 and March 8, 2016 were higher than those measured during the final four days of the test (between 0.69 and 4.3 scfm) using the Preso® meter. The moisture content within the pore spaces between the silts and fine sands that makeup the Rand stratum would have been higher during the first seven days of the test and decreased over the final four days of the test as dewatering and decreasing water levels (as measured in the nearby monitoring locations) continued until March 10 and 11, 2016, when 0.3 inches of precipitation was recorded at the Hartford Site. Ideally, more accurate vapor flowrate measurements would have been recorded during the first seven days of the test; however, this would not have impacted the outcomes of the test as the mass removal rates remained very low even during the final four days of the test when flowrate measurements were more accurately recorded using the Preso® meter. The discussion regarding air flowrate measurements has been revised accordingly in Section 4-2.		
13	4-2 – Results; Table 7	Liquid level measurements in the extraction wells were only performed for 3 out of 11 days, whereas they should have been performed at least daily during the test. Liquid levels in the extraction wells were also not recorded in Appendix C.	It is recommended that the report clarify the impacts of these data gaps on the evaluation of test performance.
Response to Comment 13	Fluid levels within the three extraction wells used during the enhanced TPE test were gauged daily to ensure that there was adequate open screen and to adjust the depth of the stingers as necessary. While the fluid level measurements within the operating wells were not recorded each day, the depth of the stinger was recorded. As summarized on Table 7, the stinger depths were adjusted only adjusted on March 4 as follows: ▪ HSVE-057: The stinger was lowered from 22.55 ft-btoc to 23.55 ft-btoc ▪ HSVE-059: The stinger was lowered from 20.40 ft-btoc to 21.5 ft-btoc ▪ HSVE-060: The stinger was raised from 22.55 ft-btoc to 20.60 ft-btoc. It should be noted that a minimum of two feet of open screen was maintained within each of the three extraction wells throughout the enhanced TPE test. As discussed in the Response to Comment No. 9, during fluid level gauging the vacuum within the operating well is disrupted resulting in lower measured groundwater elevations than those present under normal casing vacuum during operation of the well. It is assumed that once the system vacuum is reapplied, the groundwater elevation increases such that the air-water interface rebounds to the approximate depth of the tip of the stinger. A footnote has been added to Table 7 and the text in Section 4.1 has been modified to explain the qualitative nature of the fluid level measurements within the operating extraction wells. It should also be noted that the water extraction rates and fluid levels (when available) were similar between the operating wells, indicating steady state fluid level conditions throughout the enhanced TPE test. Furthermore, the groundwater elevations within the adjacent monitoring locations (HMW-004, HMW-0248B, and MP-085B) continuously decreased, supporting that the percent open screen was at a minimum stable and more than likely increasing in each of the extraction wells over the course of the test. The missing fluid level measurements from the operating wells during the first several days of the enhanced TPE test would not affect the outcome nor the interpretation of the test results.		

Apex Oil Company, Inc. Response to USEPA Comments
Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report
Hartford Petroleum Release Site, Hartford, Illinois

Comment Number	Sub-section	Topics of Discussion	Recommended Revisions
14	Table 7 and Figures 4 and 5	The locations and distances of monitoring wells HMW-004, HMW-048B and MP-085B are not shown in relation to the test extraction wells.	It is recommended that monitoring wells HMW-004, HMW-048B and MP-085B locations be added to Figures 4 and 5.
Response to Comment 14	These location of monitoring wells HMW-004 and HMW-048B, as well as multipurpose monitoring point MP-085B have been added to Figures 4 and 5.		
Section 5.0 Vapor Collection System Evaluation			
15	Figure 20.	Vapor probes vacuum monitoring results. Vapor probe identification numbers are not shown on the figure.	It is recommended that the vapor probe identification numbers be added to Figure 20.
Response to Comment 15	The vapor probe locations and identifications that were used to create the four vacuum distribution isopleth maps for Zone 6 included on Figure 20 have been provided on Figure 4. It would not be feasible to add the individual locations or identifications to the isopleth maps provided on Figure 20.		
16	5.2 - Volatile Hydrocarbon Distribution And Mass Recovery Rates	The report lacks mass recovery rates information and related discussions.	It is recommended that the report be modified to add information on mass recovery rates.
Response to Comment 16	This section has been revised to state: "The mass recovery rates for Zone 6, provided on Table 2, can be summarized as follows: ▪ May 2015 – Mass removal rates were estimated at eight operating SVE wells and varied between 0 and 1000 pounds per day (lbs/day) with the highest mass recovery reported within well HSVE-099. ▪ September 2015 – Mass removal rates were estimated at four operating SVE wells and varied between 3.3 and 550 lbs/day with the highest mass recovery reported within well HSVE-099 ▪ November 2015 – Mass removal rates were estimated at four operating SVE wells and varied between 0 and 860.2 lbs/day with the highest mass recovery reported within well HSVE-099. ▪ February 2016 - Mass removal rates were estimated at five operating SVE wells and varied between 0 and 371.3 lbs/day with the highest mass recovery reported within well HSVE-077."		
17	5-2	Re: "*Operation of additional SVE wells near well HSVE-099 would likely improve mass recovery within Zone 6* ." Agreed. However, it will only address a small area near HSVE-099 leaving the majority of Zone 6 wells at present state with low recovery rates.	It is recommended that the report be modified to indicate that the additional well will only address a small area near HSVE-099 leaving the majority of Zone 6 wells at present state with low recovery rates.
Response to Comment 17	Apex concurs that operation of any additional SVE well may only affect an area proximal to the additional extraction well. Therefore, as indicated in Section 5.4, Apex recommends connecting and operating extraction wells HSVE-001D and HSVE-030S, as well as evaluating the need for an additional extraction well to the west of wells HSVE-075 and HSVE-076.		

Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
18	5-3 – Vapor Recovery Using Temporary Tubing	It is not clear whether vapor recovery using temporary tubing has any significant effect.	Use of temporary vapor recovery tubing is not recommended in the future.
Response to Comment 18	Apex concurs that the use of temporary tubing is not recommended in the future. As discussed in Section 5-3, during the 2012 time period, mass removal rates were the highest observed since startup of the SVE system. This is primarily attributed to historical low groundwater conditions during this time period. However, there was also a focused effort to improve mass recovery by connecting multipurpose monitoring points, groundwater monitoring wells, and large diameter recovery wells to the SVE system using aboveground, temporary tubing. While it is not recommended that this process be reintroduced, mass recovery during 2012 was evaluated to determine if the locations used for vapor recovery using temporary tubing in Zone 6 would be ideal for an additional SVE well. This same approach was used when evaluating the placement of additional SVE wells in Zone 1 as part of the optimization efforts performed in 2014. Section 5.3 has been revised accordingly.		
19	5-4 - Wells HSVE-001S/D and HSVE-030S/D	Re: "*Plug and abandon SVE Well HSVE-030D.*" It is not clear what would be gained by this action. For example, this well could potentially be used by future remedies such as Multiphase Extraction (MPE).	Retain this well for potential future repurposing.
Response to Comment 19	Based on the results of the enhanced TPE test it is unlikely that extraction well HSVE-030D would be used to recover petroleum hydrocarbons from the Rand stratum in the future. However, this well will be retained unless it is determined that a more appropriately screened well within this portion of Zone 6 would improve mass recovery and require the use of the transmission lines that are currently connected to well HSVE-030D. A separate request to plug and abandon well HSVE-030D would be made to the USEPA and Illinois EPA if the use of the transmission lines currently connected to this well were proposed to be used for newly installed extraction well.		
Section 6.0 Recommendations			
20	Page 6-1 Para 2 Bullet 1	See Comment 6.	See Comment 6.
Response to Comment 20	Please refer to the response to Comment No. 6.		
21	NA	Re: "*The enhanced TPE test showed that increasing the rate of water intake would allow for sporadic operation of the deeper SVE wells installed within Zone 6, under seasonal low water level conditions. However, the rate of water recovery compared to the rate of hydrocarbon mass recovery indicates that this approach is not practicable* ." The results of the test were inconclusive due to the various deficiencies in the design and implementation of the enhanced TPE test. Therefore, the test results cannot be used as a basis for this conclusion.	It is recommended that this text be removed from the report and be replaced with text that reflects the review comments provided.

Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
Response to Comment 21	As discussed during the teleconference on August 12, 2016, the enhanced TPE test was conducted in an effort to improve the operability of wells in Zone 6 that are screened within the Rand stratum along North Olive Avenue. The enhanced TPE test was designed to determine if increasing the water extraction rates within select wells would allow: (1) well screens to be exposed, (2) unsaturated conditions to be maintained within the extraction wells and nearby monitoring locations, and (3) mass removal rates to be significantly enhanced. The enhanced TPE test was not conducted to evaluate the applicability of TPE across the Hartford Site. It should be noted that TPE is already successfully implemented within numerous wells that makeup the vapor collection system, specifically TPE has been employed within 59 operating wells over the last two years. The report has been revised to clarify the purpose of the enhanced TPE test and to highlight that any conclusions stemming from the enhanced TPE test are only applicable to wells screened in the Rand stratum in Zone 6.		
22	NA	Re: "*Therefore, Apex is recommending to continue to operate the extraction wells in Zone 6 as described within the Final Vapor Collection System OMM Plan (Trihydro 2015)* ." Without significant changes, such as installation of a water treatment system, the operation would have to be continued in an SVE mode. Absent that strategic change, the current SVE system operations could be optimized.	It is recommended that the report be modified to include specific recommendations for optimizing the current SVE system.
Response to Comment 22	As discussed during the teleconference on August 12, 2016, the purpose of this report was to identify potential modifications for components of the vapor collection system in Zone 6 that could be implemented given the constraints of the thermal treatment system located on the Premcor facility. While the enhanced TPE test did <u>not</u> indicate that significantly increasing water intake would improve mass recovery for wells installed within the Rand stratum along North Olive Avenue, there were several other specific recommendations that were provided within Section 6 for improving mass recovery within Zone 6 including: (1) connecting wells HSVE-001D and HSVE-030S to the Phase III transmission lines, (2) installing seven additional vapor monitoring probes, as well as monitoring two additional existing vapor monitoring probes to better assess vacuum distribution and total volatile petroleum hydrocarbon concentrations within the central portions of Zone 6, and (3) evaluating installation of two additional extraction wells, the first to the north of well HSVE-099 and the second to the west of wells HSVE-075 and HSVE-076, based on the additional monitoring suggested in Item No. 2.		
23	NA	Re: "*Connect SVE wells HSVE-001D and HSVE-030S to the Phase III transmission lines* ."	It is recommended that the report include a drawing that indicates how such a connection would be performed.
Response to Comment 23	A separate deliverable that provides plans and specifications for connecting wells HSVE-001D and HSVE-030S to the Phase III transmission lines will be prepared and submitted to the USEPA and Illinois EPA upon approval of this recommendation and meeting with the Village of Hartford to review the proposed construction activities. The detailed plans and specifications would then be used to solicit bids from subcontractors.		
24	NA	Re: "*While concurrently abandoning extraction wells HSVE-001S and HSVE-030D* ."	Retain well HSVE-030D for potential future repurposing.
Response to Comment 24	Please refer to the response to Comment No. 19.		

ATTACHMENT B

USEPA COMMENTS DATED OCTOBER 4, 2016 AND APEX OIL COMPANY, INC. RESPONSE DATED OCTOBER 13, 2016

EPA Secondary Review Comments on Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
General			
G-1	N/A	Apex Oil Company, Inc. (Apex) responses to EPA's review comments are generally satisfactory.	No additional report revisions are recommended.
G-2	N/A	EPA previously commented on certain technical deficiencies regarding the design and implementation of the Enhanced Total Phase Extraction Test.	It is recommended that Apex submit a work plan for EPA review prior to implementing any significant technical tasks such as testing, remedy modifications and design changes. It is further recommended that prior review comments on the design and implementation of the Enhanced Total Phase Extraction Test should be used to support any future design and planning of similar testing activities.
Section 1.0 Introduction			
EPA 1	1.0 Page 1-3 Para 1	Re: "*These wells have not been operable largely due to occlusion of the well screen with groundwater over time. This occurs despite an extensive effort to install stingers within the extraction wells and recover groundwater via total phase extraction (TPE) instead of operating the wells to solely recover vapors, as originally designed*." Without effective dewatering, these extraction wells are too deep to be used.	It is recommended that the report clarify that if significant changes aimed towards improving dewatering are made (e.g., installation of a water treatment system), the wells with the occluded screens could be made operational.
Apex Response to Comment 1	Apex concurs that the HSVE wells with occluded screens could be operational if there were significant changes to the groundwater treatment infrastructure. Such changes would require construction of a system capable of continuous treatment and discharge of water at flow rates one to two orders-of-magnitude higher than the average accumulation rate at the thermal treatment system currently located on the Premcor facility adjacent to the Village of Hartford. However, the results of the enhanced total phase extraction (TPE) test, did not indicate that significantly increasing the groundwater extraction rates from the three vapor recovery wells screened in the Rand stratum and located on North Olive Avenue in Soil Vapor Extraction (SVE) Effectiveness Zone 6 (Zone 6) would result in a significant increase in the mass recovery of volatile petroleum hydrocarbons. The enhanced TPE test was performed during a period of low groundwater elevations in the Rand stratum and in a portion of Zone 6 that contains light non-aqueous phase liquids (LNAPL) and associated elevated concentrations of petroleum and non-petroleum related hydrocarbons in the dissolved and vapor phases.		
EPA Response	EPA concurs with Apex's response to EPA Comment 1.		

EPA Secondary Review Comments on Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
EPA 2	1.1 Purpose Para 1 Bullet 1	Re: "*Reevaluation of the three dimensional (3D) visualization of the geologic setting underlying Zone 6. A detailed 3D visualization analysis of the lithology described during installation of soil borings was prepared and subsequently compared to the generalized 3D stratigraphic interpretation of the geologic setting. These 3D visualization analyses were compared to determine if there are additional geologic factors that may be affecting efforts to recover volatile hydrocarbons in specific locations in Zone 6* ."	The revision of the three-dimensional visualization analysis (3DVA) based on the reinterpretations of the original boring logs should provide the basis for more accurate understanding of site heterogeneity. It is recommended that 3DVA continue to be used to support future evaluations of removal efficiencies of all contaminant phases (LNAPL, dissolved, vapor) from within specific zones and wells, in relation to screened intervals and lithologies.
Apex Response to Comment 2	Apex concurs that the reevaluation of the three dimensional (3D) visualization of the lithology beneath the Hartford Site can, in some cases, provide a more nuanced understanding of site heterogeneities, that may support future evaluations of hydrocarbon mass removal and losses and may serve as a useful tool to communicate site conditions to stakeholders. As indicated in Section 6 (Recommendations) if specific data gaps are identified in the conceptual site model that may be resolved through further evaluation of the detailed 3D visualization analysis of the lithology, then additional modeling may be performed in focused portions of the Hartford Site, similar to the analysis completed for Zone 6.		
EPA Response	EPA concurs with Apex's response to EPA Comment 2.		

EPA Secondary Review Comments on Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
Section 2 Background			
EPA 3	2.1.2; Table 1	Table 1 presents a summary of the soil vapor extraction wells construction and settings.	It is recommended that the stinger depths be added to this table.
Apex Response to Comment 3	Stinger depths are periodically (as often as semi-weekly) adjusted in response to fluctuations in the groundwater table and as such are continually in a state of flux. Stinger depths and adjustments are provided within Appendix A of the *Semiannual Soil Vapor Extraction (SVE) System Operations, Maintenance, and Monitoring (OMM) Report* .		
EPA Response	EPA concurs with Apex's response to EPA Comment 3.		
EPA 4	2.1.2 Soil Vapor Extraction	This section presents a general summary of Zone 6 soil vapor extraction (SVE) operations.	Applied vacuum is an important operational parameter for SVE. It is recommended that a description of the applied vacuum levels measured during the test be added to this section.
Apex Response to Comment 4	This section was intended to provide an overview of SVE operations within Zone 6, specifically to highlight the challenges associated with continuously operating individual extraction wells installed within the Rand stratum and was not intended to provide specifics regarding the day-to-day operation and monitoring of SVE wells across the Hartford Site. Details regarding operating parameters are highly variable due to fluctuations in the groundwater table and are provided within Appendix A of the *Semiannual SVE System OMM Report* .		
EPA Response	EPA concurs with Apex's response to EPA Comment 4.		
Section 3.0 Site Setting			
EPA 5	3.1.1 Generalized Stratigraphic Interpretation Page 3-3 Figure 9	Re: "*In addition, a 3D isopach map of the generalized stratigraphy showing the clay, silt, and sand units is included on Figure 9* ."	It is recommended that these 3DVA approaches and outputs continue to be used to evaluate the site and to communicate site conditions to stakeholders, as specified in Comment Numbers 6 and 7. Given the current condition of the site, it may provide additional benefit in the future to apply integrated 3DVA (geology, hydrogeology and contamination [all phases as applicable]) at the strategic and larger-scale evaluation levels as the remedy progresses, and to present the results using this approach to lithologic visualization.
Apex Response to Comment 5	Please refer to the Response to Comment No. 2.		

EPA Secondary Review Comments on Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
EPA Response	EPA concurs with Apex's response to EPA Comment 5.		
EPA 6	3.1.2 Detailed Lithologic Interpretation Page 3-5 Figures 7 and 8	Re: "*While the detailed lithologic interpretation depicts a more nuanced and discontinuous setting within the upper 40 feet of the subsurface compared to the generalized stratigraphic interpretation, it is not any more accurate in showing the actual geology, as reported within the borings installed via Cone Penetration Testing* ."	Use of Cone Penetrometer Testing data may be beneficial in the future, but should not wholly replace 3DVA of "actual geology" based on USCS Soil Types data. Further, if 3DVA of detailed lithology using numeric value equivalents to represent USCS Soil Types is to be continued, it is recommended that these data equivalents be used to visualize the heterogeneity based on "actual geology" versus emulating the approach of representing geology expressed as the distribution of relative hydraulic conductivity (K_R). The K_R approach, however, may provide greater benefit in the future when remediation is more specifically focused on the distribution, fate and transport of dissolved phase contamination.
Apex Response to Comment 6	Apex concurs that the use of cone penetrometer testing (CPT) data, or similar geophysical data (e.g., electrical conductivity) could be useful to resolve specific data gaps related to the Hartford Site. Apex also agrees that such geophysical data does not replace the use of 3D visualization of the lithologic setting. As discussed in Section 3.1.2 and further described in Appendix A, the USCS soil types were converted to a numerical value based on relative grain size and sorting with the soil types comprised of the smallest grain size (i.e., high plasticity clays, fat clays) assigned a value of 1 and largest grain size (i.e., well graded sands or gravelly sands) assigned a value of 16. During the teleconference between 212 Environmental Consulting, LLC, United States Environmental Protection Agency (USEPA), and Titrates conducted on April 13, 2016, it was agreed that a whole number numeric value would be used to depict the USCS soil types within the revised 3D visualization of the lithology underlying Zone 6. It is likely that the numeric value equivalents used in the revised 3D visualization of the lithology underlying Zone 6 would be consistent with a reinterpretation of the 3D visualization of lithology performed using a distribution of relative hydraulic conductivities for each UCSC Soil Type. It should be noted that the hydraulic conductivity for a given UCSC Soil Type can span several orders of magnitude (http://www.geotechdata.info/parameter/permeability.html).		
EPA Response	EPA concurs with Apex's response to EPA Comment 6.		

EPA Secondary Review Comments on Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
EPA 7	3.1.2 Detailed Lithologic Interpretation Page 3-5 Figures 7 and 8	Re: "*Although the model provides a better sense of the distribution of glaciofluvial deposits in the shallower portions of the subsurface, detailed analyses using existing lithologic logs and additional soil borings will be necessary when designing new recovery wells at the Hartford Site* ."	It is agreed that the boring logs from any future borings should be used to design wells and screened intervals. However, it is recommended that 3DVA be used as a line of evidence to support the identification of locations for any new borings at the site, as well as to help determine what target depths to drill to.
Response to Comment 7	Please refer to the Response to Comment No. 2.		
EPA Response	EPA concurs with Apex's response to EPA Comment 7.		
Section 4.0 Enhanced Total Phase Extraction Test			
EPA 8	4-1 – Methods; Table 7	Depth to water in all extraction wells is at least twice that of the available vacuum lift, which should make the ability to remove water from a well impossible based on the current methods described. It is presumed that there must be some method element(s) missing from the descriptions.	It is recommended that the report clarify the method of water removal used during the test to resolve the review observation. Include details such as stinger height adjustment to initiate and maintain the process and the use of dilution valves to control the process. Clarify whether an airlift method was used, and if so, describe how the method is inherently unstable when it relies on vacuum and is a process that can easily shut down if adequate air flow is unavailable.
Apex Response to Comment 8	It is recognized that vacuum lift for the SVE system at the Hartford Site (with a typical maximum operating vacuum of 100 in-H2O) could not recover groundwater at depths greater than approximately 8 feet below ground surface. Therefore, an airlift method is employed wherein air moving at high velocity entrains water droplets at the air-water interface and conveys them upward into the horizontal conveyance line. The terminal end of each stinger consists of a beveled tip which allows for continued airflow at high velocity and reduces the likelihood of shutting down (i.e., deadheading) while the stinger is incrementally lowered. Using visual and auditory cues from water flowing through the transparent tubing at the stinger head, the field technicians gradually lowers the stinger to a target depth within the vertical well screen, stopping when a steady flow of water is observed within the stinger. While regional groundwater fluctuations have the potential to result in unstable flow conditions, these were not observed during the duration of the enhanced TPE test. It should be noted that the stinger depths are periodically (as often as semi-weekly) adjusted in response to fluctuations in the groundwater table and as such are continually in a state of flux. Stinger depths and adjustments are provided within Appendix A of the *Semiannual SVE OMM Report* . Section 4-1 was revised to include this discussion regarding water withdrawal during the enhanced TPE test.		
EPA Response	EPA concurs with Apex's response to EPA Comment 8.		

EPA Secondary Review Comments on Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
EPA 9	4-1 – Methods; Table 7	Water levels in all extraction wells are approximately 1 foot above the bottom of the stinger tubes. It would be impossible to remove water via a stinger under this scenario.	Please clarify on Table 7 the actual stinger depths versus the liquid/air interface position and provide the rationale for any discrepancies.
Apex Response to Comment 9	As shown on Table 7, water levels within each of the extraction wells used during the Enhanced TPE test are approximately 1 foot **below** the bottom of the stingers. It is important to understand that fluid level measurements collected within each of the SVE wells are estimated values as the vacuum must either be disrupted or shutdown prior to gauging the fluid level within the operating wells. In the case of the three extraction wells used for the enhanced TPE test, there is a small sample port in each of the well caps that is utilized for fluid level measurements. The cap is removed from the sample port and an interface probe is quickly lowered to air-water interface; however, this process temporarily disrupts the casing vacuum, and likely results in lower measured groundwater elevations than those present under normal casing vacuum during operation of the well. It is assumed that once the system vacuum is reapplied, the groundwater elevation increases such that the air-water interface rebounds to the approximate depth of the tip of the stinger. A footnote has been added to Table 7 and the text in Section 4.1 has been modified to explain the qualitative nature of the fluid level measurements within the operating extraction wells.		
EPA Response	The method of measuring water levels within the extraction wells provides unreliable data and EPA concurs with Apex explaining that the data are qualitative. It would be more effective to measure water levels via use of dedicated, submersible pressure transducers / data loggers.		
EPA 10	4-1 – Methods; Figure 19	Water removal rates and air flows were measured once per day by temporarily connecting the 40-gallon knock-out tank and a flowmeter to the vacuum header. The majority of the measurements were performed using 5-minute intervals per day for each well. This method would not provide reliable data because the water removal rates and air flows during the majority of operation would differ from those during the short-time measurement intervals. More reliable data would be obtained by using an electrical pump operated by level switches and a flow totalizer to evacuate liquid from the knock-out tank in a continuous flow fashion during the test.	It is recommended that the report clarify the limitations of data representativeness for water removal rates and air flow measurements obtained during knock-out tank performance testing and that as a result, the water removal rates and totals volumes provided are order-of-magnitude estimates.

EPA Secondary Review Comments on Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
Apex Response to Comment 10	It is agreed that more sophisticated techniques for estimating groundwater extraction rates, such as described within Comment No. 10, may provide more accurate water removal rates. However, the extraction wells used for the enhanced TPE test are located within North Olive Avenue (an active roadway) within the Village of Hartford and as such, long term measurements or continuous measurements would not be safe or practical. In addition to the water removal rates estimated using the in-line knockout tank, water removal rates were also measured within the Main Header transmitting all of the recovered soil vapor and groundwater to the thermal treatment system located on the Premcor facility. Prior to the start of the test, the water removal rate for the entire SVE system was 1,000 gallons per day (gpd) as recorded on February 29, 2016. During the enhanced TPE test the water removal rate increased to between 2,600 and 2,800 gpd. Following the enhanced TPE test, the water removal rate decreased to 1,400 gpd, as recorded on March 14, 2016. Note that towards the end of the test, the river stage increased and precipitation was recorded (a total of 0.3 inches), which would have also resulted in increased water removal rates following completion of the test. Based on the aggregate measurements recorded within the Main Header, it is estimated that the combined water removal rate from the three wells utilized during the enhanced TPE test were between 1,200 to 1,800 gpd. The estimated average groundwater extraction rate for the enhanced TPE test using data collected from each well using the knockout tank was 1,963 gpd, only slightly higher than the maximum that can be estimated using aggregate flowrate measurements from the Main Header. Furthermore, the variability of the daily water removal rates recorded within the individual test wells was relatively low indicating that the measured rates were likely accurate. Based on the close agreement between the individual well and system aggregate measurements (i.e., Main Header), it appears that the flow rates reported during the test are reasonable and are not "order-of-magnitude estimates". The text in Section 4-2 has been modified to include this discussion to provide benchmarks for interpreting the water removal rates.		
EPA Response	EPA concurs with Apex's response to EPA Comment 10.		
EPA 11	4-1 - Methods	The report does not mention that electric well pumps were initially used to evacuate water from the test extraction wells. Thus, the total removal volume was unaccounted for.	It is recommended that the report include the volumes of water evacuated from each extraction well using electric well pumps.
Apex Response to Comment 11	Electric pumps were not used to initially remove groundwater from each of the extraction wells prior to performing the enhanced TPE test, rather the existing stinger within each of the wells was used to purge water from the well as described in the Response to Comment No. 8. The text within Section 4.1 as been modified to provide additional detail regarding the process of initially removing groundwater from the extraction wells prior to the start of the enhanced TPE test. The amount of water initially removed using the stinger ranged from 11.2 gallons from well HSVE-060 to 14.2 gallons from well HSVE-059, and is minor compared to the water generated during the enhanced TPE test (approximately 20,000 gallons).		
EPA Response	EPA concurs with Apex's response to EPA Comment 11.		

EPA Secondary Review Comments on Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
EPA 12	4-1 - Methods	Reliable air flow measurements could not be performed during the majority of the test due to the time elapsed during the use of, or change-out, of unsuitable measurement instrumentation.	It is recommended that the report clarify that reliable air flow measurements could not be performed during the majority of the test due to unsuitable measurement instrumentation used.
Response to Comment 12	It is agreed that the air flow measurements recorded during the first seven days of the enhanced TPE test were not as accurate as measurements collected thereafter due to the high range of the Dwyer gauges (0-100 and 0-50 scfm), as discussed in Section 4-1. During the first four days of the test (March 1 through March 4, 2016) airflow was measured using a Dwyer VFLO venturi flowmeter equipped with a magnehelic gauge that provided a broad range for measuring air flowrate (0-100 scfm) with the lowest scale reading at 20 scfm. A smaller range magnehelic gauge (0-50 scfm) was acquired and used for measurements collected on March 7 and 8. Therefore, it is possible that airflow was occurring between 0 and 20 scfm during the first four days and between 0 and 10 scfm on March 7 and 8th but could not be accurately measured with the magnehelic gauges. However, it is unlikely that the air flowrates recorded between March 1 and March 8, 2016 were higher than those measured during the final four days of the test (between 0.69 and 4.3 scfm) using the Preso® meter. The moisture content within the pore spaces between the silts and fine sands that makeup the Rand stratum would have been higher during the first seven days of the test and decreased over the final four days of the test as dewatering and decreasing water levels (as measured in the nearby monitoring locations) continued until March 10 and 11, 2016, when 0.3 inches of precipitation was recorded at the Hartford Site. Ideally, more accurate vapor flowrate measurements would have been recorded during the first seven days of the test; however, this would not have impacted the outcomes of the test as the mass removal rates remained very low even during the final four days of the test when flowrate measurements were more accurately recorded using the Preso® meter. The discussion regarding air flowrate measurements has been revised accordingly in Section 4-2.		
EPA Response	EPA concurs with Apex's response to EPA Comment 12.		
EPA 13	4-2 – Results; Table 7	Liquid level measurements in the extraction wells were only performed for 3 out of 11 days, whereas they should have been performed at least daily during the test. Liquid levels in the extraction wells were also not recorded in Appendix C.	It is recommended that the report clarify the impacts of these data gaps on the evaluation of test performance.

EPA Secondary Review Comments on Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
Apex Response to Comment 13	Fluid levels within the three extraction wells used during the enhanced TPE test were gauged daily to ensure that there was adequate open screen and to adjust the depth of the stingers as necessary. While the fluid level measurements within the operating wells were not recorded each day, the depth of the stinger was recorded. As summarized on Table 7, the stinger depths were adjusted only adjusted on March 4 as follows: ▪ HSVE-057: The stinger was lowered from 22.55 ft-btoc to 23.55 ft-btoc ▪ HSVE-059: The stinger was lowered from 20.40 ft-btoc to 21.5 ft-btoc ▪ HSVE-060: The stinger was raised from 22.55 ft-btoc to 20.60 ft-btoc. It should be noted that a minimum of two feet of open screen was maintained within each of the three extraction wells throughout the enhanced TPE test. As discussed in the Response to Comment No. 9, during fluid level gauging the vacuum within the operating well is disrupted resulting in lower measured groundwater elevations than those present under normal casing vacuum during operation of the well. It is assumed that once the system vacuum is reapplied, the groundwater elevation increases such that the air-water interface rebounds to the approximate depth of the tip of the stinger. A footnote has been added to Table 7 and the text in Section 4.1 has been modified to explain the qualitative nature of the fluid level measurements within the operating extraction wells. It should also be noted that the water extraction rates and fluid levels (when available) were similar between the operating wells, indicating steady state fluid level conditions throughout the enhanced TPE test. Furthermore, the groundwater elevations within the adjacent monitoring locations (HMW-004, HMW-0248B, and MP-085B) continuously decreased, supporting that the percent open screen was at a minimum stable and more than likely increasing in each of the extraction wells over the course of the test. The missing fluid level measurements from the operating wells during the first several days of the enhanced TPE test would not affect the outcome nor the interpretation of the test results.		
EPA Response	EPA concurs with Apex's response to EPA Comment 13.		
EPA 14	Table 7 and Figures 4 and 5	The locations and distances of monitoring wells HMW-004, HMW-048B and MP-085B are not shown in relation to the test extraction wells.	It is recommended that monitoring wells HMW-004, HMW-048B and MP-085B locations be added to Figures 4 and 5.
Apex Response to Comment 14	These location of monitoring wells HMW-004 and HMW-048B, as well as multipurpose monitoring point MP-085B have been added to Figures 4 and 5.		
EPA Response	EPA concurs with Apex's response to EPA Comment 14.		

EPA Secondary Review Comments on Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
Section 5.0 Vapor Collection System Evaluation			
EPA 15	Figure 20.	Vapor probes vacuum monitoring results. Vapor probe identification numbers are not shown on the figure.	It is recommended that the vapor probe identification numbers be added to Figure 20.
Apex Response to Comment 15	The vapor probe locations and identifications that were used to create the four vacuum distribution isopleth maps for Zone 6 included on Figure 20 have been provided on Figure 4. It would not be feasible to add the individual locations or identifications to the isopleth maps provided on Figure 20.		
EPA Response	EPA concurs with Apex's response to EPA Comment 15.		
EPA 16	5.2 - Volatile Hydrocarbon Distribution And Mass Recovery Rates	The report lacks mass recovery rates information and related discussions.	It is recommended that the report be modified to add information on mass recovery rates.
Apex Response to Comment 16	This section has been revised to state: "The mass recovery rates for Zone 6, provided on Table 2, can be summarized as follows: ▪ May 2015 – Mass removal rates were estimated at eight operating SVE wells and varied between 0 and 1000 pounds per day (lbs/day) with the highest mass recovery reported within well HSVE-099. ▪ September 2015 – Mass removal rates were estimated at four operating SVE wells and varied between 3.3 and 550 lbs/day with the highest mass recovery reported within well HSVE-099 ▪ November 2015 – Mass removal rates were estimated at four operating SVE wells and varied between 0 and 860.2 lbs/day with the highest mass recovery reported within well HSVE-099. ▪ February 2016 - Mass removal rates were estimated at five operating SVE wells and varied between 0 and 371.3 lbs/day with the highest mass recovery reported within well HSVE-077."		
EPA Response	EPA concurs with Apex's response to EPA Comment 16.		

EPA Secondary Review Comments on Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
EPA 17	5-2	Re: "*Operation of additional SVE wells near well HSVE-099 would likely improve mass recovery within Zone 6* ." Agreed. However, it will only address a small area near HSVE-099 leaving the majority of Zone 6 wells at present state with low recovery rates.	It is recommended that the report be modified to indicate that the additional well will only address a small area near HSVE-099 leaving the majority of Zone 6 wells at present state with low recovery rates.
Apex Response to Comment 17	Apex concurs that operation of any additional SVE well may only affect an area proximal to the additional extraction well. Therefore, as indicated in Section 5.4, Apex recommends connecting and operating extraction wells HSVE-001D and HSVE-030S, as well as evaluating the need for an additional extraction well to the west of wells HSVE-075 and HSVE-076.		
EPA Response	EPA concurs with Apex's response to EPA Comment 17.		
EPA 18	5-3 – Vapor Recovery Using Temporary Tubing	It is not clear whether vapor recovery using temporary tubing has any significant effect.	Use of temporary vapor recovery tubing is not recommended in the future.
Apex Response to Comment 18	Apex concurs that the use of temporary tubing is not recommended in the future. As discussed in Section 5-3, during the 2012 time period, mass removal rates were the highest observed since startup of the SVE system. This is primarily attributed to historical low groundwater conditions during this time period. However, there was also a focused effort to improve mass recovery by connecting multipurpose monitoring points, groundwater monitoring wells, and large diameter recovery wells to the SVE system using aboveground, temporary tubing. While it is not recommended that this process be reintroduced, mass recovery during 2012 was evaluated to determine if the locations used for vapor recovery using temporary tubing in Zone 6 would be ideal for an additional SVE well. This same approach was used when evaluating the placement of additional SVE wells in Zone 1 as part of the optimization efforts performed in 2014. Section 5.3 has been revised accordingly.		
EPA Response	EPA concurs with Apex's response to EPA Comment 18.		
EPA 19	5-4 - Wells HSVE-001S/D and HSVE-030S/D	Re: "*Plug and abandon SVE Well HSVE-030D.*" It is not clear what would be gained by this action. For example, this well could potentially be used by future remedies such as Multiphase Extraction (MPE).	Retain this well for potential future repurposing.

EPA Secondary Review Comments on Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
Apex Response to Comment 19	Based on the results of the enhanced TPE test it is unlikely that extraction well HSVE-030D would be used to recover petroleum hydrocarbons from the Rand stratum in the future. However, this well will be retained unless it is determined that a more appropriately screened well within this portion of Zone 6 would improve mass recovery and require the use of the transmission lines that are currently connected to well HSVE-030D. A separate request to plug and abandon well HSVE-030D would be made to the USEPA and Illinois EPA if the use of the transmission lines currently connected to this well were proposed to be used for newly installed extraction well.		
EPA Response	EPA concurs with Apex's response to EPA Comment 19.		
Section 6.0 Recommendations			
EPA 20	Page 6-1 Para 2 Bullet 1	See Comment 6.	See Comment 6.
Apex Response to Comment 20	Please refer to the response to Comment No. 6.		
EPA Response	EPA concurs with Apex's response to EPA Comment 20.		
EPA 21	NA	Re: "*The enhanced TPE test showed that increasing the rate of water intake would allow for sporadic operation of the deeper SVE wells installed within Zone 6, under seasonal low water level conditions. However, the rate of water recovery compared to the rate of hydrocarbon mass recovery indicates that this approach is not practicable* ." The results of the test were inconclusive due to the various deficiencies in the design and implementation of the enhanced TPE test. Therefore, the test results cannot be used as a basis for this conclusion.	It is recommended that this text be removed from the report and be replaced with text that reflects the review comments provided.

EPA Secondary Review Comments on Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
Apex Response to Comment 21			
EPA Response	EPA concurs with Apex's response to EPA Comment 21.		

EPA Secondary Review Comments on Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
EPA 22	NA	Re: "*Therefore, Apex is recommending to continue to operate the extraction wells in Zone 6 as described within the Final Vapor Collection System OMM Plan (Trihydro 2015)* ." Without significant changes, such as installation of a water treatment system, the operation would have to be continued in an SVE mode. Absent that strategic change, the current SVE system operations could be optimized.	It is recommended that the report be modified to include specific recommendations for optimizing the current SVE system.
Apex Response to Comment 22	As discussed during the teleconference on August 12, 2016, the purpose of this report was to identify potential modifications for components of the vapor collection system in Zone 6 that could be implemented given the constraints of the thermal treatment system located on the Premcor facility. While the enhanced TPE test did <u>not</u> indicate that significantly increasing water intake would improve mass recovery for wells installed within the Rand stratum along North Olive Avenue, there were several other specific recommendations that were provided within Section 6 for improving mass recovery within Zone 6 including: (1) connecting wells HSVE-001D and HSVE-030S to the Phase III transmission lines, (2) installing seven additional vapor monitoring probes, as well as monitoring two additional existing vapor monitoring probes to better assess vacuum distribution and total volatile petroleum hydrocarbon concentrations within the central portions of Zone 6, and (3) evaluating installation of two additional extraction wells, the first to the north of well HSVE-099 and the second to the west of wells HSVE-075 and HSVE-076, based on the additional monitoring suggested in Item No. 2.		
EPA Response	EPA previously recommended that the report be modified to include specific recommendations for optimizing the current SVE system. Apex reiterated several minor changes to the SVE system operation that did not constitute true optimization of the current SVE system. These minor changes in the SVE operation as described in the current report do not provide an effective SVE system optimization. It is recommended that Apex include a more robust SVE system optimization approach in future remedy evaluation efforts, which should be possible within the context of a comprehensive remedial strategy. **For this Zone 6 optimization effort, the Agencies recommend the installation of additional SVE wells in areas of the system where multiple wells are not generally operable. A well screened in the North Olive somewhere between HSVE-055 and HSVE-058; a well located between HSVE-058 and HSVE-064; a well located between HSVE-064 and HSVE-067; a well located between HSVE-067 and HSVE-076. The distance between the proposed HSVE-001D connection and HSVE-109 appears far enough apart that incorporation of an additional SVE well west of HSVE-075 is appropriate without further evaluation.**		
EPA 23	NA	Re: "*Connect SVE wells HSVE-001D and HSVE-030S to the Phase III transmission lines* ."	It is recommended that the report include a drawing that indicates how such a connection would be performed.

EPA Secondary Review Comments on Apex Oil Company, Inc. Response to USEPA Comments Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report Hartford Petroleum Release Site, Hartford, Illinois			
Comment Number	**Sub-section**	**Topics of Discussion**	**Recommended Revisions**
Apex Response to Comment 23	A separate deliverable that provides plans and specifications for connecting wells HSVE-001D and HSVE-030S to the Phase III transmission lines will be prepared and submitted to the USEPA and Illinois EPA upon approval of this recommendation and meeting with the Village of Hartford to review the proposed construction activities. The detailed plans and specifications would then be used to solicit bids from subcontractors.		
EPA Response	EPA concurs with Apex's response to EPA Comment 23.		
EPA 24	NA	Re: "*While concurrently abandoning extraction wells HSVE-001S and HSVE-030D* ."	Retain well HSVE-030D for potential future repurposing.
Apex Response to Comment 24	Please refer to the response to Comment No. 19.		
EPA Response	EPA concurs with Apex's response to EPA Comment 24.		

October 13, 2016

Ms. Michelle Kaysen
United States Environmental Protection Agency Region 5
Mail Code LU-9J
77 West Jackson Boulevard
Chicago, Illinois 60604

RE: Response to USEPA's Secondary Review Comments on Apex Oil Company, Inc. Response to USEPA Comments, Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report, Hartford Petroleum Release Site, Hartford, Illinois

Dear Ms. Kaysen,

212 Environmental Consulting, LLC (212 Environmental), on behalf of Apex Oil Company, Inc. (Apex), received USEPA's *Secondary Review Comments on Apex Oil Company, Inc. Response to USEPA Comments, Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report* (Secondary Review Comments) on October 4, 2016. Within the October 4, 2016 correspondence, the USPEA provided an additional comment in response to Apex's response to USEPA's Comment No. 22 regarding the *Vapor Extraction System Effectiveness Zone 6 Optimization Report, Hartford Petroleum Release Site, Hartford, Illinois (Zone 6 Optimization Report)*. Apex appreciates this opportunity to respond to USEPA's Second Review Comment. USEPA's initial Comment No. 22, Apex's initial response, and USEPA's Secondary Review Comments, are provided below as background.

USEPA Comment No. 22: It is recommended that the report be modified to include specific recommendations for optimizing the current SVE system.

> ***Apex Response to USEPA Comment No. 22***: As discussed during the teleconference on August 12, 2016, the purpose of this report was to identify potential modifications for components of the vapor collection system in Zone 6 that could be implemented given the constraints of the thermal treatment system located on the Premcor facility. While the enhanced TPE test did not indicate that significantly increasing water intake would improve mass recovery for wells installed within the Rand stratum along North Olive Avenue, there were several other specific recommendations that were provided within Section 6 for improving mass recovery within Zone 6 including: (1) connecting wells HSVE-001D and HSVE-030S to the Phase III transmission lines, (2) installing seven additional vapor monitoring probes, as well as monitoring two additional existing vapor monitoring probes to better assess vacuum distribution and total volatile petroleum hydrocarbon concentrations within the central portions of Zone 6, and (3) evaluating

installation of two additional extraction wells, the first to the north of well HSVE-099 and the second to the west of wells HSVE-075 and HSVE-076, based on the additional monitoring suggested in Item No. 2.

USEPA Secondary Review Comment: EPA previously recommended that the report be modified to include specific recommendations for optimizing the current SVE system. Apex reiterated several minor changes to the SVE system operation that did not constitute true optimization of the current SVE system. These minor changes in the SVE operation as described in the current report do not provide an effective SVE system optimization. It is recommended that Apex include a more robust SVE system optimization approach in future remedy evaluation efforts, which should be possible within the context of a comprehensive remedial strategy. For this Zone 6 optimization effort, the Agencies recommend the installation of additional SVE wells in areas of the system where multiple wells are not generally operable. A well screened in the North Olive somewhere between HSVE-055 and HSVE-058; a well located between HSVE-058 and HSVE-064; a well located between HSVE-064 and HSVE-067; a well located between HSVE-067 and HSVE-076. The distance between the proposed HSVE-001D connection and HSVE-109 appears far enough apart that incorporation of an additional SVE well west of HSVE-075 is appropriate without further evaluation.

Apex Response to USEPA's Secondary Review Comments: Specific recommendations for optimizing the operation of the soil vapor extraction (SVE) system within Zone 6 were included within the draft and revised *Zone 6 Optimization Report*. These recommendations included the installation of two new SVE wells (HSVE-108 and HSVE-109), in addition to connecting and activating two existing extraction wells (HSVE-001D and HSVE-030S), which have been inoperable, to the Phase III transmission lines in Zone 6. In total, Apex recommended bringing four additional SVE wells online in Zone 6, as shown on the attached Figure 1, resulting in a total of 29 extractions wells that would be potentially operable in Zone 6. For reference, only 12 extraction wells were operated in Zone 6 between April 2015 and September 2016.

The proposed locations for the additional SVE wells were selected based on a review of the total volatile petroleum hydrocarbon concentrations measured in the North Olive stratum during quarterly effectiveness monitoring, coupled with the mass recovery from the operating extraction wells. Specifically, Apex's proposed expansion of the vapor collection system targets areas with elevated total volatile petroleum hydrocarbon concentrations and low mass recovery rates. A summary of the range of total volatile petroleum hydrocarbon concentrations reported in the monitoring locations and the mass recovery rate within the operating extraction wells between the second quarter 2015 and third quarter 2016 are summarized on the attached Figure 1. This figure also includes colored isopleths depicting the distribution of total volatile petroleum hydrocarbons measured during the November 2015 quarterly effectiveness monitoring event.

ENVIRONMENTAL

Besides expansion of the extraction well network, Apex recommends installing and routine monitoring within seven new vapor monitoring probes, as well as two existing multipurpose monitoring points (MP-106A and MP-109B) as part of the quarterly effectiveness monitoring program (Figure 1). This would allow further evaluation of the fixed gas and total volatile petroleum hydrocarbon concentrations, as well as vacuum distribution within the central portions of Zone 6. The intent is to collect additional routine monitoring data to determine if further optimization of the vapor collection system would be beneficial within this portion of Zone 6. The operation of four additional extraction wells and routine monitoring within nine additional vapor monitoring probes and multipurpose monitoring points constitutes optimization of the current SVE system.

To address any remaining concerns by the Agencies, Apex has evaluated USEPA's recommended locations for the installation of four additional extraction wells along North Olive Avenue within the North Olive stratum "where multiple wells are not generally operable". Specifically, the USEPA recommended the following:

- A well located between HSVE-055 and HSVE-058
- A well located between HSVE-058 and HSVE-064
- A well located between HSVE-064 and HSVE-067, and
- A well located between HSVE-067 and HSVE-076

The location of the four additional SVE wells were considered in the context of: (i) total volatile petroleum hydrocarbon concentrations measured within the effectiveness monitoring network since the second quarter 2015, (ii) the location and mass recovery rate of petroleum hydrocarbons within the current operable SVE wells since the second quarter 2015, and (iii) the location of the four extraction wells which Apex proposes to add to the SVE system, specifically wells HSVE-001D, HSVE-030S, HSVE-108, and HSVE-109.

Based on this evaluation, Apex concurs with the installation and connection of two additional SVE wells in the northern portion of Zone 6 between HSVE-055 and HSVE-058 and between HSVE-058 and HSVE-064. This will increase the total number of new operating wells to six within Zone 6, reflecting more than a 50% expansion of the operating wells in this portion of the Hartford Site. The two proposed locations, designated HSVE-110 and HSVE-111 on the attached Figure 1, are within the extent of elevated total volatile petroleum hydrocarbon concentrations and reduced vapor recovery using existing extraction wells. Note that it will be difficult to install these wells within North Olive Avenue, as the roadway was recently repaved by the Village of Hartford. However, installation of these two wells on private property at locations proximal to North Olive Avenue may be more feasible and acceptable to the Village of Hartford. The two proposed extraction wells (HSVE-110 and HSVE-111) are depicted on Figure 1 to be in close proximity to North Olive Avenue, but the actual location may be modified during design and/or installation.

At this time, Apex does not support installation of additional wells between existing wells HSVE-064 and HSVE-067 or between existing wells HSVE-067 and HSVE-076 because such additional wells would not improve mass recovery or provide additional protection to residents located in these portions of Zone 6. The area between existing wells HSVE-064 and HSVE-067 does not exhibit high total volatile petroleum hydrocarbon concentrations and an additional well would not optimize the system's performance. Furthermore, an additional extraction well located between existing wells HSVE-067 and HSVE-076 would be redundant in light of Apex's previously proposed extraction well HSVE-109 (see Figure 1). Based on available data, it is unlikely that siting the two additional SVE wells within the North Olive stratum at the proposed locations would result in substantial recovery of additional volatile petroleum hydrocarbons. However, following the installation of the four additional wells (HSVE-108 through HSVE-111) and the new connection of the two existing wells (HSVE-001D and HSVE-030S), if the routine effectiveness monitoring data suggests that additional extraction wells would substantially increase volatile petroleum hydrocarbon mass recovery, then Apex will include further recommendations for optimizing the vapor collection system in Zone 6 within the semiannual reports summarizing operations, monitoring, and maintenance activities for the SVE system. Recommendations for optimizing the SVE system in other portions of the Hartford Site were recently provided within the draft *Semiannual Soil Vapor Extraction System Operations, Maintenance, and Monitoring Report, October 2015 through March 2016, Hartford Petroleum Release Site, Hartford Illinois* (212 Environmental 2016).

If you have any questions regarding this response, please contact Paul Michalski at (513) 430-1766 or me at (307) 760-1803.

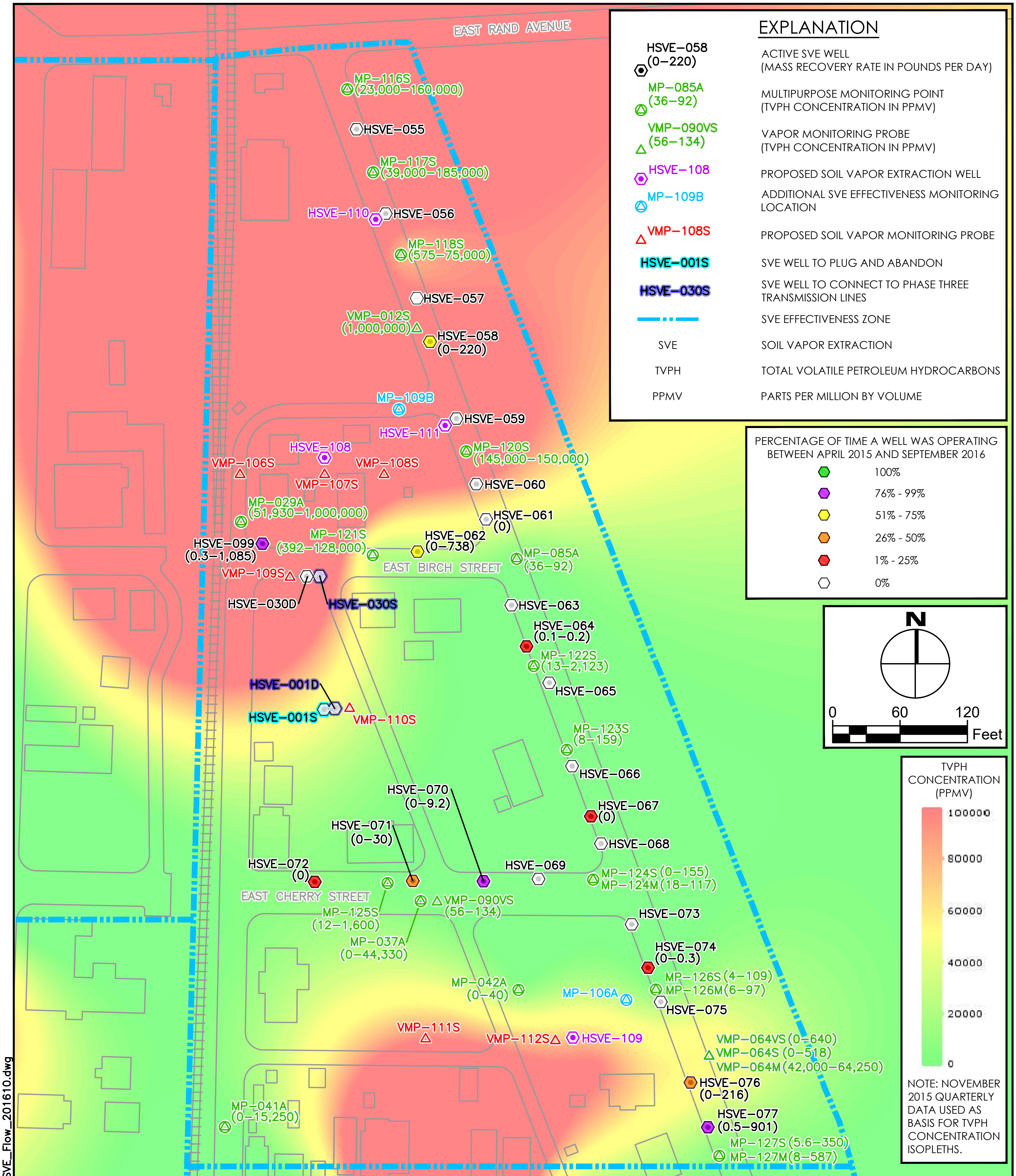
Sincerely,
212 Environmental Consulting, LLC

Shannon Thompson

Shannon Thompson, P.E.
Senior Chemical Engineer

Attachment

cc: James F. Sanders, Apex Oil Company, Inc.
Tom Miller, Illinois Environmental Protection Agency



TITLE: FIGURE 1. RANGE OF TVPH CONCENTRATIONS, SVE WELL RECOVERY RATES, AND TVPH DISTRIBUTION	1" = 120' SCALE.	16-001-07 PROJECT NO.	10/11/16 DATE.
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS	JGP DRAWN.	SLT CHECKED.	REV. 0 REVISION.

DRAFT

TWOONETWO ENVIRONMENTAL
816 Delta Avenue
Cincinnati, Ohio 45226
(513) 430-1766

FILE: 00107_01_TVPH_SVE_Flow_201610.dwg

ATTACHMENT C

USEPA EMAIL DATED OCTOBER 14, 2016, APEX OIL COMPANY INC. RESPONSE DATED OCTOBER 26, 2016, and USEPA FINAL CORRESPONDENCE DATED OCTOBER 27, 2016

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

October 27, 2016
Via email

To: Paul Michalski, 212 Environmental
Shannon Thompson, 212 Environmental
James Sanders, Apex Oil Co.

From: Michelle Kaysen, US EPA

Subject: *Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report, Hartford Petroleum Release Site, Hartford, Illinois*

On October 13, 2016, Apex provided a response to EPA's secondary comments on the Draft SVE Zone 6 Report. EPA commented on that response via email on 10/14/16 and Apex responded on 10/26/16 via email. That exchange in reproduced below for the record.

In response to EPA's last comment regarding the dynamic nature of the vapor plume(s), Apex suggested that plume behavior could exhibit changes due to "the presence of alternate petroleum hydrocarbon sources."

To more specifically highlight the Agency's point, EPA is attaching historic HWG vapor plume maps (EVS maps) depicting FID readings within the North Olive Stratum between January 2009 – February 2011. The dynamic nature of the soil vapor plume is *site-wide* and has existed throughout the course of EPA's involvement in various investigations. These maps demonstrate the high degree of variability associated with vapor movement.

Although Apex acknowledges other variables beyond alternate sources, the dynamic nature of vapor movement or migration at Hartford is extensive both spatially and temporally.

Email exchange between EPA and Apex on 10/14 and 10/26, respectively:

EPA:

As clarification, the revised report (Aug 2016) did *not* propose to install HSVE-108 and 109. It proposed to connect the existing wells, 001D and 030S, and to "further evaluate placement of two additional SVE wells....the necessity...will be further considered." The Agencies believe these wells *are* necessary and agree with your response provided.

Regarding the two wells requested by the Agencies on the southern leg of the North Olive St line, the following information was considered:

Referencing the Semiannual SVE OMM Report (9/9/16), there appears to be some discrepancies between Table 2 and Appendix A. For example, for some wells Table 2 reports "well was not operating during this time period"; however, Appendix A contains reporting data.

-HSVE-74 on Table 2 is reported as not operating during November 2015. App. A shows that on 11/18/15, this well measured 530 ppmv TVPH.

-This should be resolved to provide for a more transparent review of data.

Apex:

Soil vapor samples are collected within Tedlar bags from SVE wells on a monthly basis and field screened for total volatile petroleum hydrocarbons (TVPH) and fixed gases (oxygen, carbon dioxide, and methane) in accordance with the procedures outlined in the *Final Vapor Collection System Operation, Maintenance, and Monitoring Plan* (*VCS OMM Plan*) dated September 4, 2015. Soil vapor samples are collected from any extraction well with an exposed screen (i.e., unoccluded with groundwater), regardless if the well is being operated or not operated. However, if the screen interval within an extraction well is determined to be occluded with groundwater, then a soil vapor sample is not collected for field screening purposes.

Collection of measurements to estimate the flow rate within an extraction well is only performed if the well is operating at the time that monitoring is performed. Within Appendix A of the *Semiannual Soil Vapor Extraction System Operations, Maintenance, and Monitoring Report, October 2015 through March 2016 (Semiannual SVE OMM Report, October 2015 through March 2016)*, operating wells will be reported with a header valve position that is greater than 0% (with the exception of SVE wells that contain a straw stinger) indicating that the well was open and had an applied vacuum at the time the measurement was collected. For wells with a straw stinger, the main header valve position will generally be set at 0%, as the vacuum is directed through the straw stinger. In these cases, the straw stinger valve position would indicate whether the well was operational. As reported in Appendix A of the *Semiannual SVE OMM Report, October 2015 through March 2016*, the header valve and straw stinger valve positions (reported in columns W and X, respectively) for SVE well HSVE-074 (which contains a Viton stinger), was reported at 0%, and therefore this extraction well was not operating on the date in question (November 18, 2015). However, the well screen within HSVE-074 was not occluded with groundwater and therefore a soil vapor sample was collected within a Tedlar bag for field screening purposes on this same day. The well was subsequently brought online on November 20, 2015 and operated until December 29, 2015.

To calculate mass recovery, both the flow rate and TVPH concentration need to have been collected from an extraction well, preferably on the same day. As noted on Table 2 included in the *Semiannual SVE OMM Report, October 2015 through March 2016*, extraction well HSVE-074 was not operational in November 2015, consistent with the notes included in Appendix A. For clarity, future summary tables will include the TVPH field screening results irrespective of the operational status of a well during a monitoring event.

EPA:
Within the area of concern, HSVE-73 has measured >10,000 TVPH according to Table 1 of the OMM Plan (9/2015), presenting summary data from 2014 – mid-2015. There is no data available for HSVE-73 in the 2016 SVE OMM report. HSVE-68 measured between 100-1,000 TVPM between 2014 – mid-2015. Again, there's no data available from the SVE OMM report. It is possible that this area is impacted by the transient nature of the vapor migration within this area regionally.

Apex:
As described, soil vapor samples are not collected for field screening purposes from SVE wells if the screen interval is occluded with groundwater. The screen interval in extraction wells HSVE-068 and HSVE-073 were occluded with groundwater and therefore these wells were not operated between October 2015 and March 2016. Therefore, there was no field screening or flow rate measurements collected from these wells over the reporting period, as shown in Appendix A of the *Semiannual SVE OMM Report, October 2015 through March 2016*.

It is important to note that when evaluating areas that may be underlain by petroleum hydrocarbons, field screening results reported from the multipurpose monitoring points and nested vapor monitoring probes is considered more representative of subsurface conditions compared to the screening results collected from the extraction wells. TVPH concentrations measured within operating SVE wells may be biased high due to the extended pneumatic influence of these wells. Furthermore, extraction wells HSVE-068 and HSVE-073 are screened in the Rand stratum. The USEPA recommended installation of additional extraction wells in the shallower North Olive stratum within this portion of Effectiveness Zone 6. Vapor monitoring locations screened in the North Olive stratum near extraction wells HSVE-068 and HSVE-073 include monitoring points MP-123S, MP-124S/M, and MP-126S/M. The maximum TVPH concentration measured in these locations since April 2015 is 159 ppmv, which is not indicative of a significant source of volatile petroleum hydrocarbons. As discussed, routine monitoring will be performed in the North Olive stratum in this portion of Effectiveness Zone 6 to determine if conditions might warrant installation of additional extraction wells in the future.

EPA:
The multipurpose monitoring point TVPH data presented on the attached figure doesn't appear to correlate with the November 2015 data presented in the SVE OMM Report, App. F1. Where can this data, used for the attached Figure 1, be located?

Apex:
Attached is a summary of the November 2015 screening results used to develop the TVPH isopleths depicted on the figure included within the response to the USEPA Secondary Review Comments. There were three locations with collocated wells screened within the North Olive stratum that were used to generate the TVPH isopleths on this figure (multipurpose monitoring points MP-124S/M, MP-126S/M, and 127S/M). At these three locations, the TVPH concentrations measured within the middle monitoring location (designated as "M") was used for creating the isopleths.

It should be noted that the TVPH concentrations that are provided in parentheses next to each monitoring location on the figure included with the response to the USEPA Secondary Review Comments represent the range of TVPH screening results measured between May 2015 and September

2016. The TVPH data recorded during each of the effectiveness monitoring events is also provided in the corresponding semiannual SVE OMM reports.

EPA:

You stated that multiple lines of evidence where used in the placement of the proposed SVE wells, including dissolved phase and LIF. Although the recent dissolved phase sample from the shallow unit at MP-85 is non-detect, that is the only sample collected from this area during the dissolved phase investigation (212 July 2016). Regarding LIF data, it does not appear as if any of the 2013 LIF borings were collocated with the 2005 LIF investigation in this area (Figure 17 LCSM). However, the 2005 ROST investigation showed that south of HROST-010, the borings demonstrated a very small shallow LIF response. HROST-76 had a small response at 4'; HROST-15 had a small response at 14.5'; and HROST-22 had a small response at 17'.

Apex:

The USEPA is correct that the nearest monitoring location where dissolved phase data is available within the North Olive stratum is reported from monitoring point MP-085A. There are not any other groundwater monitoring wells or multipurpose monitoring points screened within the North Olive stratum that can be sampled along North Olive Avenue between East Birch and East Cherry Streets. The remaining monitoring locations in this area are constructed with between 1/8-inch or 1/2-inch diameter tubing from which a representative groundwater sample cannot be collected.

The USEPA is also correct that a collocated laser induced fluorescence boring was not installed in this portion of Zone 6 in 2013. However, there does not appear to be any measurable fluorescence response within the North Olive stratum present in borings HROST-015, HROST-022, or HROST-076 during the investigation performed in 2004. The depths that are identified by the USEPA in these three borings are simply the call-out locations that were randomly selected by the operator during installation of the borings. The scale on the graphs showing the individual waveforms on the right hand side of the attached logs, indicates individual waveform response between 0.000 and 0.001 volts at these shallow depths, which is indicative of a background fluorescence response. The scale is similar on call-out No. 4 at a depth of 56.47 feet on the log for HROST-015. The combined fluorescence waveform for each of these borings indicates that petroleum hydrocarbons are first measured at a depth of approximately 30 feet below ground surface.

EPA:

Given the ROST data, the dissolved phase data point, the general TVPH trends in HSVE-64 and 67, **we can agree** to the request to omit additional wells in this area with the condition that monitoring data will be used to reevaluate the need later.

Apex:

Apex will continue to monitor TVPH concentrations in this portion of Effectiveness Zone 6 during routine effectiveness monitoring events.

EPA:

However, the draft Combined Effectiveness Monitoring Plan doesn't contemplate a robust monitoring program within this area. Currently monitored are: MP-85, MP-122, MP-123, MP-124, MP-126, VMP-64. The proposed revision to the monitoring network removes all but two of those probes (MP-85 and VMP-64), both of which are proposed for quarterly monitoring. In the absence of new wells, particularly since very little extraction is happening between Birch and Cherry, we request the monitoring network retain MP-122 -- MP-126.

Apex:
As described in the *Combined Effectiveness Monitoring Plan*, dated October 7, 2016, based on analysis of the effectiveness monitoring results collected since the second quarter 2015, multipurpose monitoring points MP-112 through MP-130 have a higher frequency of leakage compared to the other monitoring locations. Shut-in testing and the integrity of connections within these multipurpose monitoring points cannot be confirmed prior to collecting vapor samples for field screening. Therefore, Apex recommended removing these locations from the effectiveness monitoring well network. In lieu of sampling these multipurpose monitoring points, Apex proposed the installation of four vapor monitoring probes in this area (VMP-112, VMP-117, VMP-118, and VMP-119), as well as including existing multipurpose monitoring point MP-106B as part of future effectiveness monitoring events. Apex believes that these modifications to the effectiveness monitoring network will provide more representative data for evaluating TVPH concentrations in the North Olive stratum in this portion of Effectiveness Zone 6.

EPA:
We do believe, from historic vapor monitoring, that vapor migration throughout the village has demonstrated a non-static condition. Plumes can be seen to come and go within areas depending upon conditions; however, the stratigraphy in this area may be having a limiting effect on that vapor behavior in the shallow units.

Apex:
Changes in LNAPL thickness, dissolved phase concentrations, and vapor phase concentrations are currently being considered in Effectiveness Zone 1. It is possible that (1) redistribution of historical LNAPL releases associated with the Hartford Site or (2) the presence of alternate petroleum hydrocarbon sources could result in changes in volatile petroleum hydrocarbon concentrations within the vadose zone, as well as changes in the migration pathway into overlying structures. There are several other factors that could also explain changes in the vapor phase concentrations in a particular area over time including significant fluctuations in groundwater elevations or changes in SVE system operations resulting in "non-static conditions". Fluctuations in LNAPL thicknesses, dissolved phase concentrations, and volatile petroleum hydrocarbon concentrations will be considered as part of the comprehensive conceptual site model for the Hartford Site, but it is likely that data gaps will remain, which may be the focus of additional data collection and analyses in the future. Collecting routine monitoring data from the effectiveness monitoring network will identify "non-static conditions" and may also help in resolving this data gap moving forward.

TABLE 1. TVPH SCREENING RESULTS, EFFECTIVENESS ZONE 6

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Zone	Strata	Date	TVPH (ppmv)
MP-029A	Zone 6	N. Olive	11/17/15	420,000
MP-037A	Zone 6	N. Olive	11/17/15	11
MP-041A	Zone 6	N. Olive	11/17/15	0
MP-042A	Zone 6	N. Olive	11/17/15	40
MP-085A	Zone 6	N. Olive	11/17/15	92
MP-116S	Zone 6	N. Olive	11/18/15	160,000
MP-117S	Zone 6	N. Olive	11/18/15	185,000
MP-118S	Zone 6	N. Olive	11/18/15	75,000
MP-120S	Zone 6	N. Olive	11/19/15	150,000
MP-121S	Zone 6	N. Olive	11/18/15	13,500
MP-122S	Zone 6	N. Olive	11/18/15	13
MP-123S	Zone 6	N. Olive	11/18/15	8
MP-124M	Zone 6	N. Olive	11/18/15	18
MP-125S	Zone 6	N. Olive	11/18/15	13
MP-126M	Zone 6	N. Olive	11/18/15	6
MP-127M	Zone 6	N. Olive	11/19/15	8
VMP-064M	Zone 6	N. Olive	11/14/15	64,250
VMP-064S	Zone 6	N. Olive	11/14/15	168
VP-004S	Zone 6	N. Olive	11/15/15	110,000

Notes:

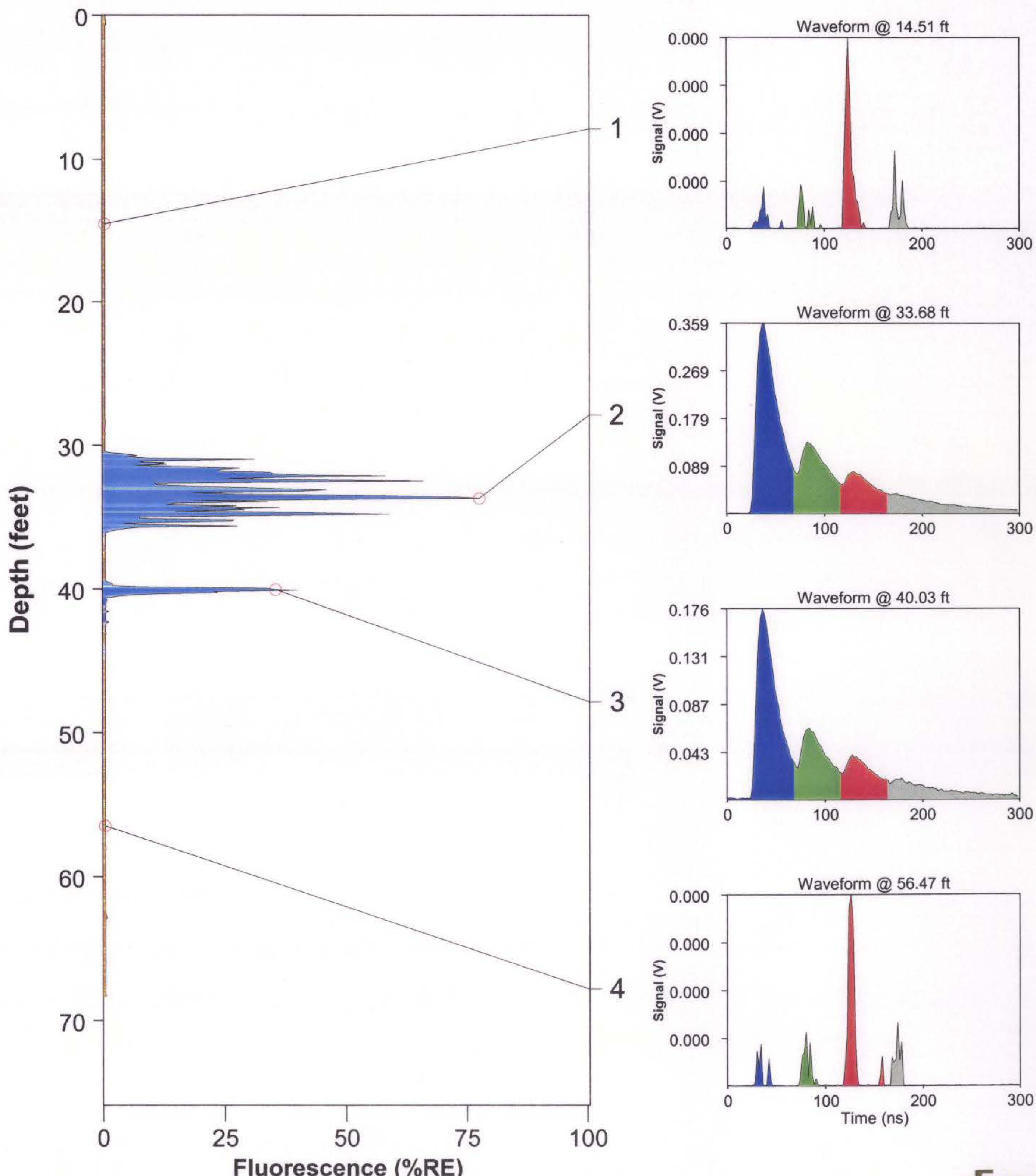
TVPH - total volatile petroleum hydrocarbons

ppmv - parts per million by volume

ROST Fluorescence Response Data

Site: Village of Hartford	Operator: ddeleon
Client: Clayton Group Services	Fugro Job #: 0303-0921
Date/Time: 2/17/2004 @ 2:32:11 PM	Max fluorescence: 77.21% @ 33.68 ft
ROST Unit: 1	Final depth BGS: 68.35 ft

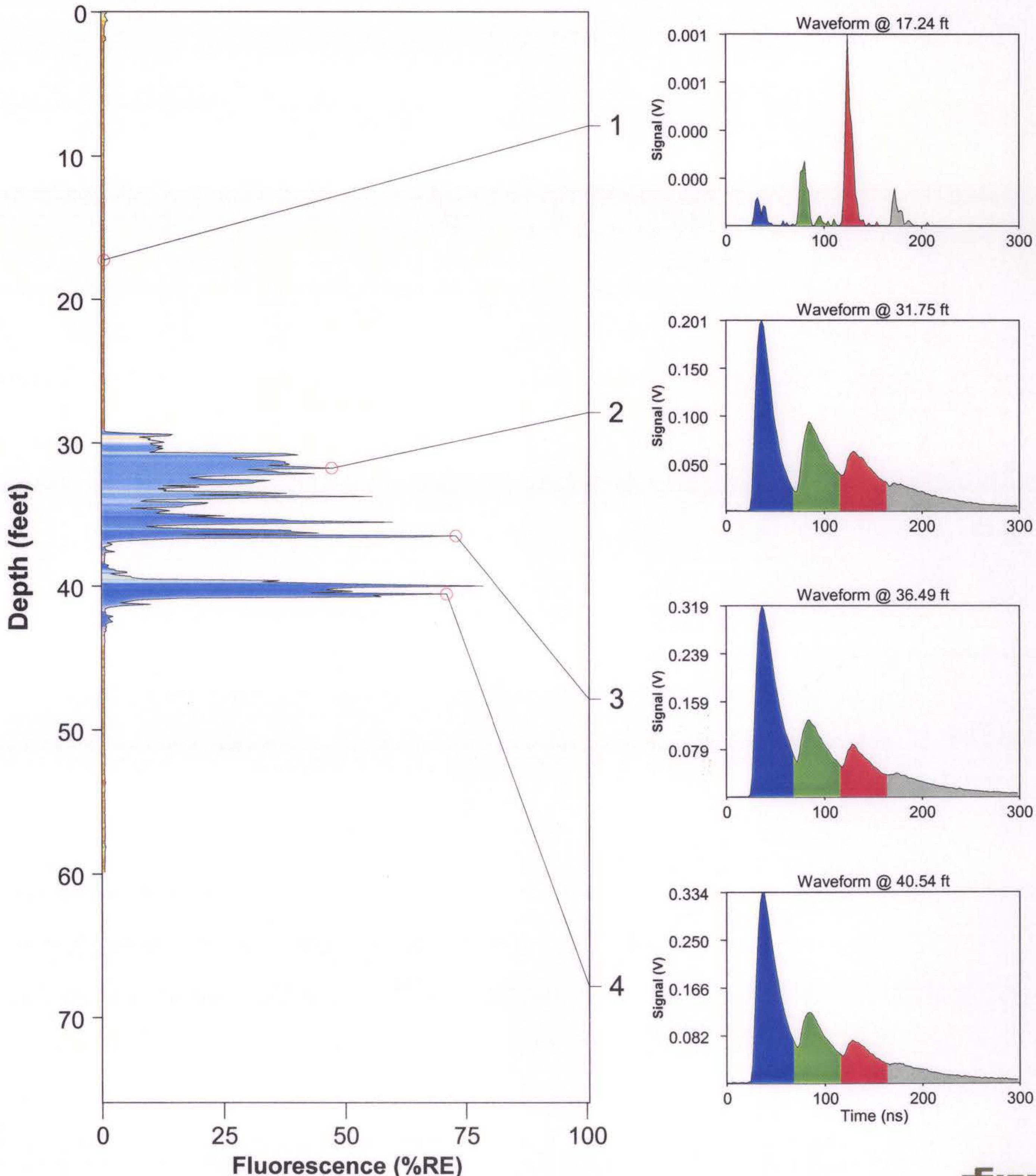
HROST-15



ROST Fluorescence Response Data

Site: Village of Hartford	Operator: ddeleon
Client: Clayton Group Services	Fugro Job #: 0303-0921
Date/Time: 2/17/2004 @ 1:41:48 PM	Max fluorescence: 78.20% @ 39.99 ft
ROST Unit: 1	Final depth BGS: 59.89 ft

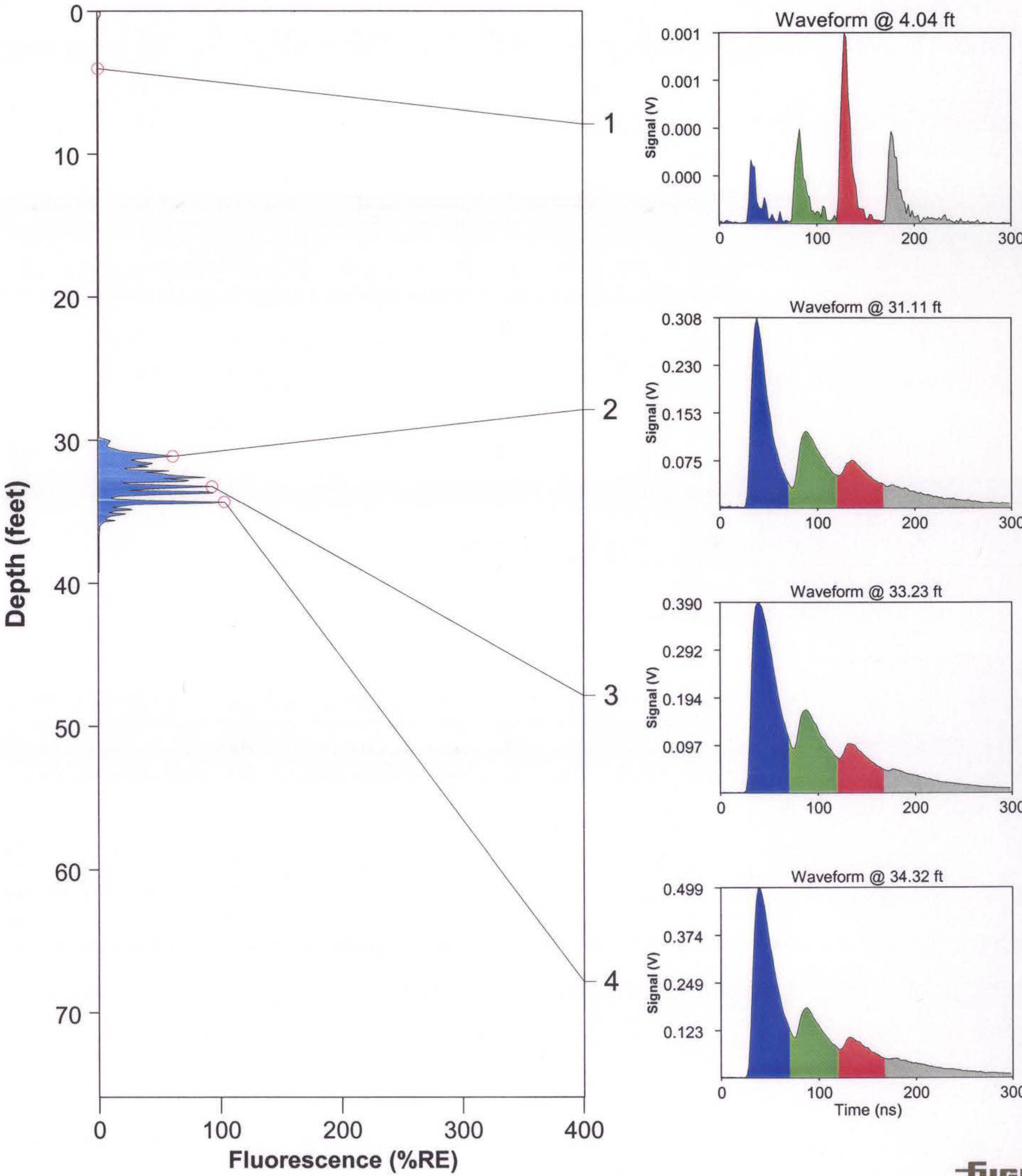
HROST-22



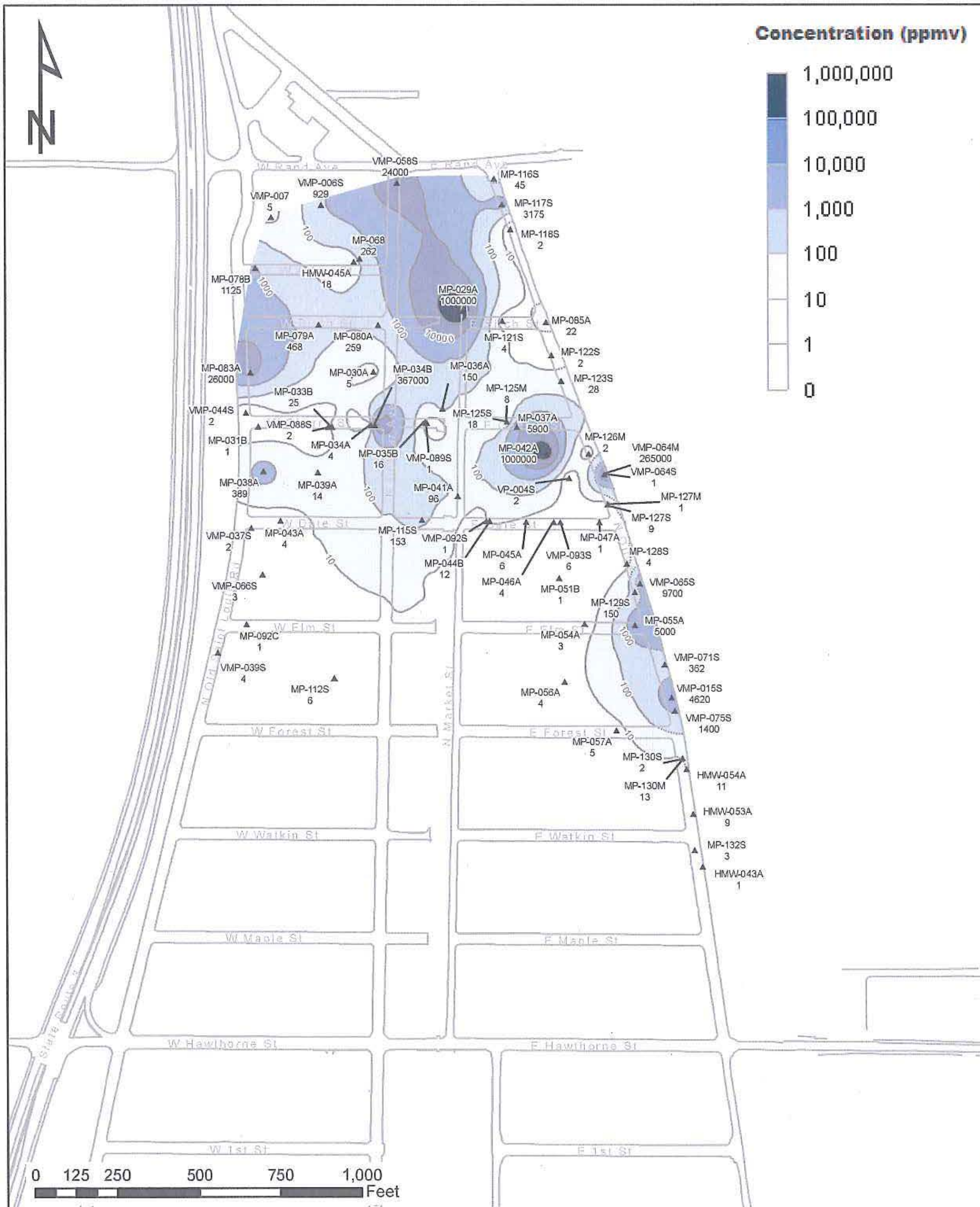
ROST Fluorescence Response Data

Site: Village of Hartford	Operator: ddeleon
Client: Clayton Group Services	Fugro Job #: 0303-0921
Date/Time: 2/21/2004 @ 12:54:24 PM	Max fluorescence: 103.45% @ 34.32 ft
ROST Unit: 1	Final depth BGS: 39.26 ft

HROST-76



Attachment
EVS Maps
North Olive Stratum



Draft
Work in Progress

These maps are being provided by the Hartford Working Group subject to the following caveats:
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Figure	Legend	FID North Olive Stratum January 2009	AECOM
3	▲ Monitoring Location and Value (ppmv) Isoconcentration Contours Manual Contours Streets Notes: Based on final data for January 2009 SVE System Effectiveness Monitoring Event.	Data Source: Provided by URS Screening Stratum Revision October 2008 Effectiveness monitoring data processed and analyzed using Environmental Visualization System PRO Version 8.54	Prepared for: Hartford Working Group Hartford, Illinois Date: March 11, 2009 Project Number: 01007-530

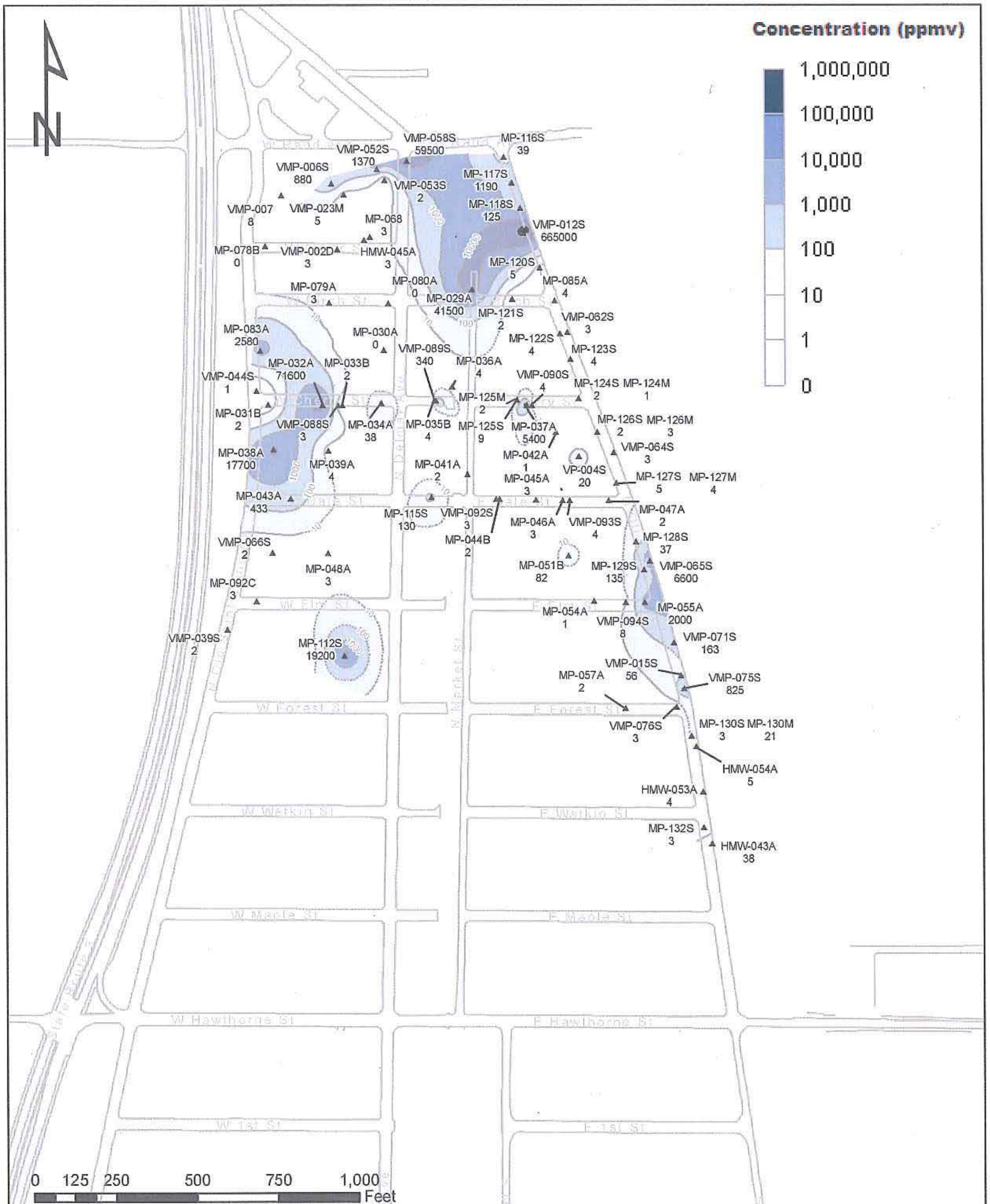

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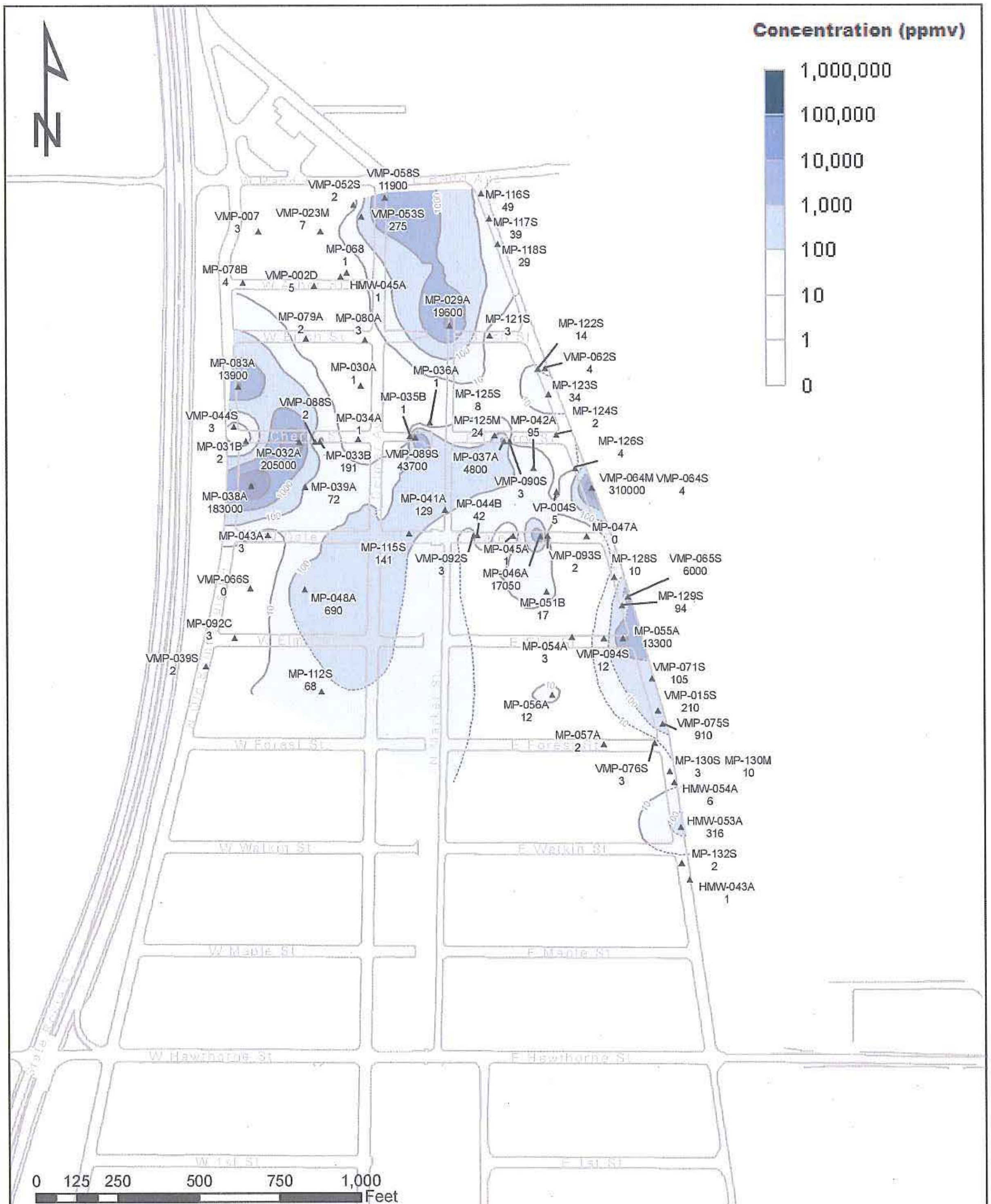
Figure	Legend	FID North Olive Stratum March 2009	AECOM
3	▲ March Monitoring Location and Value (ppmv) Isoconcentration Contours Manually Interpreted Contours Streets Notes: Based on final data for March 2009 SVE System Effectiveness Monitoring Event.	Data Source: Provided by URS Screening Stratum Revision October 2008 Effectiveness monitoring data processed and analyzed using Environmental Visualization System PRO Version 8.54	Prepared for: Hartford Working Group Hartford, Illinois Date: April 14, 2009 Project Number: 01007-530



Draft
Work in Progress

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Figure

3

Legend

- ▲ May Monitoring Location and Value (ppmv)
- Isoconcentration Contours
- Manually Interpreted Contours
- Streets

Notes:
Based on final data for May 2009
SVE System Effectiveness Monitoring Event

FID
North Olive Stratum
May 2009

Data Source:
Provided by URS
Screening Stratum Revision October 2008

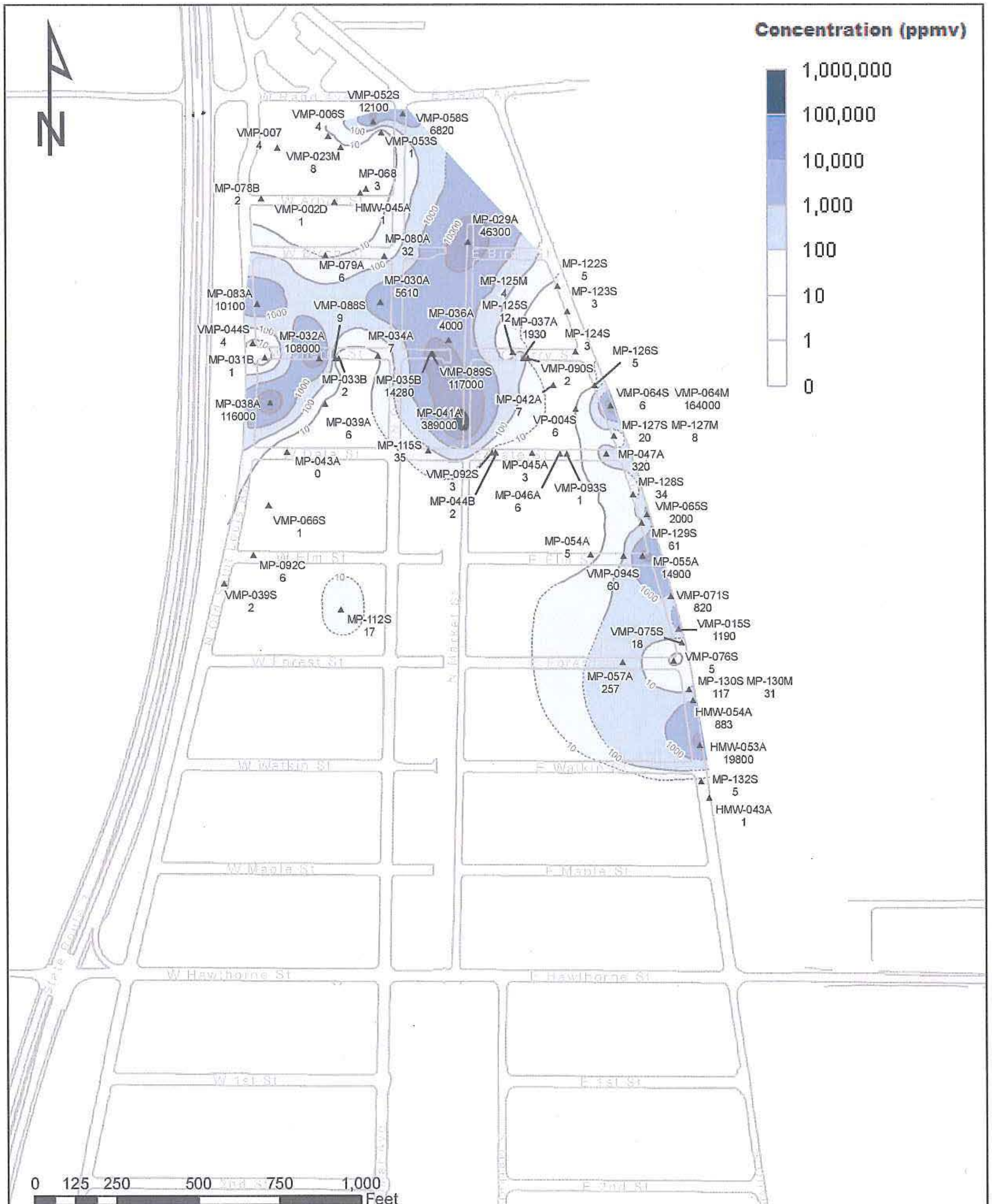
Effectiveness monitoring data processed and analyzed
using Environmental Visualization System PRO Version 8.54

AECOM

Prepared for:
Hartford Working Group
Hartford, Illinois

Date: June 30, 2009

Project Number: 01007-530



Draft
Work in Progress

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Figure 3

Legend

- ▲ June Monitoring Location and Value (ppmv)
- Isoconcentration Contours
- Manually Interpreted Contours
- Streets

Notes:
Based on final data for June 2009
SVE System Effectiveness Monitoring Event.

FID North Olive Stratum June 2009

Data Source:
Provided by URS
Screening Stratum Revision October 2008

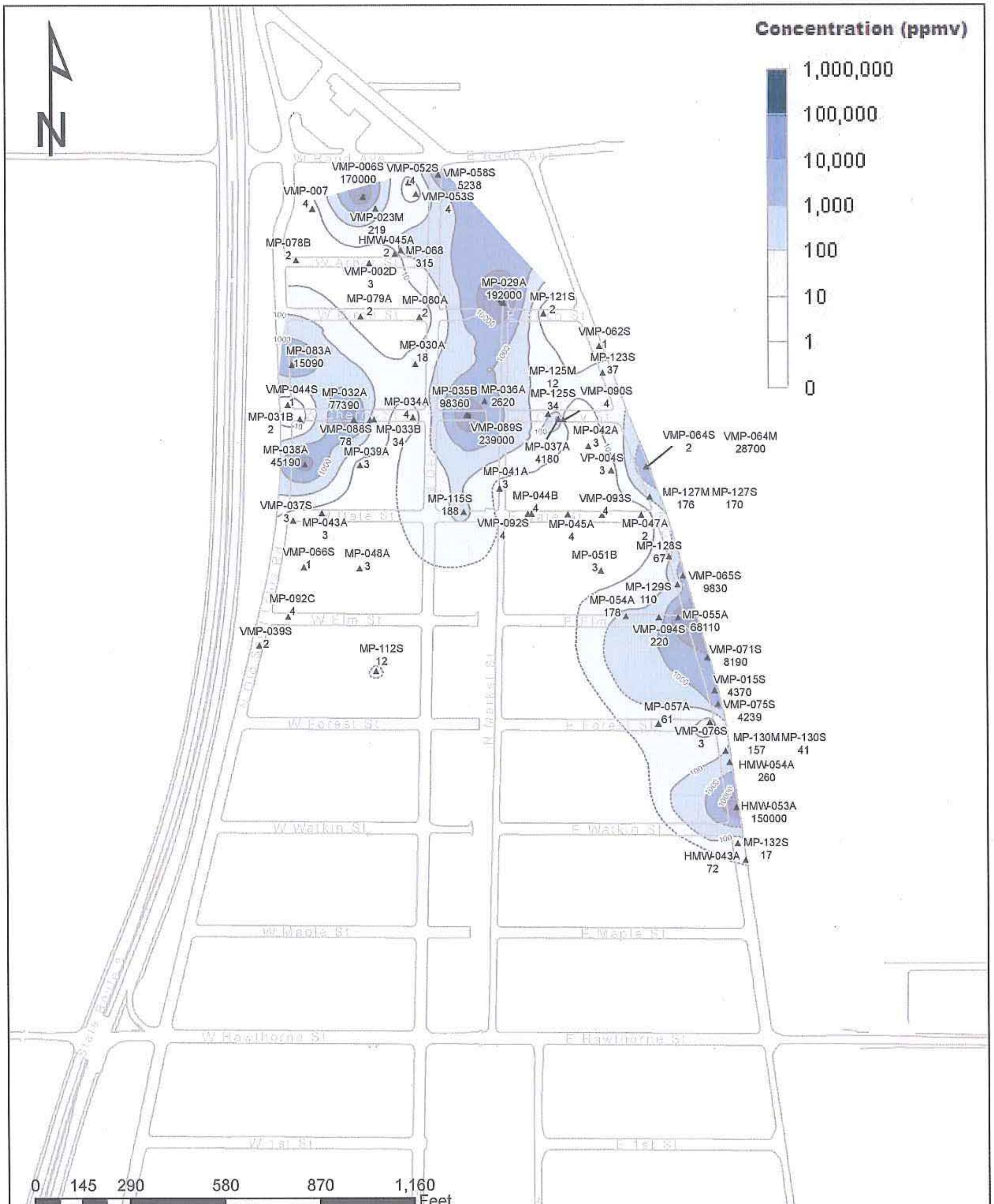
Effectiveness monitoring data processed and analyzed using Environmental Visualization System PRO Version 8.54

AECOM

Prepared for:
Hartford Working Group
Hartford, Illinois

Date: July 15, 2009

Project Number: 01007-530



Draft
Work in Progress

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Figure

3

Legend

- ▲ July Monitoring Location and Value (ppmv)
- ---------- Manual Contours
- ——— Isoconcentration Contours
- ——— Streets

Notes:
Based on final data for July 2009
SVE System Effectiveness Monitoring Event.

FID
N Olive Stratum
July 2009

Data Source:
Provided by URS
Screening Stratum Revision October 2008

Effectiveness monitoring data processed and analyzed using Environmental Visualization System PRO Version 9.13

AECOM

Prepared for:
Hartford Working Group
Hartford, Illinois

Date: August 20, 2009

Project Number: 01007-530

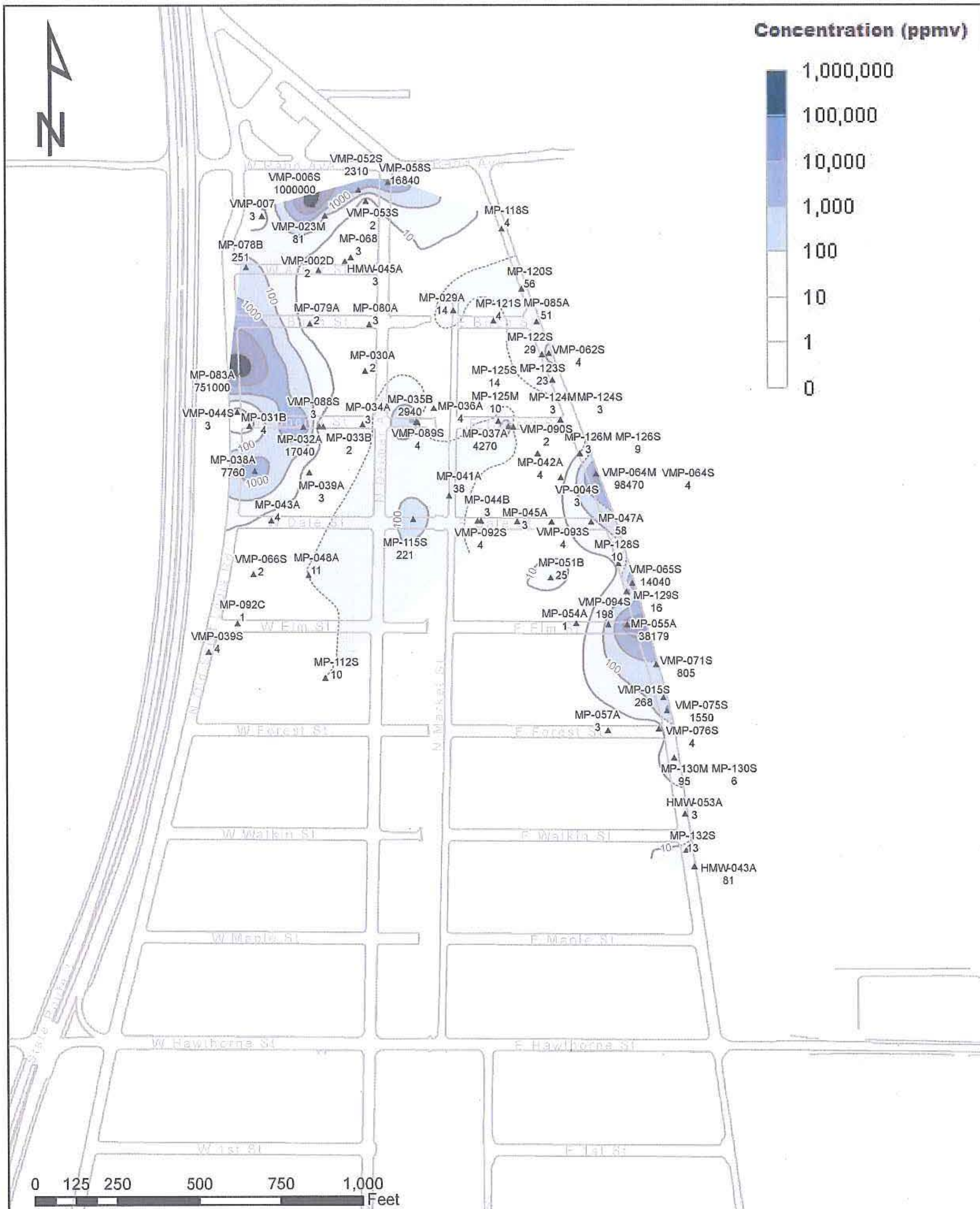

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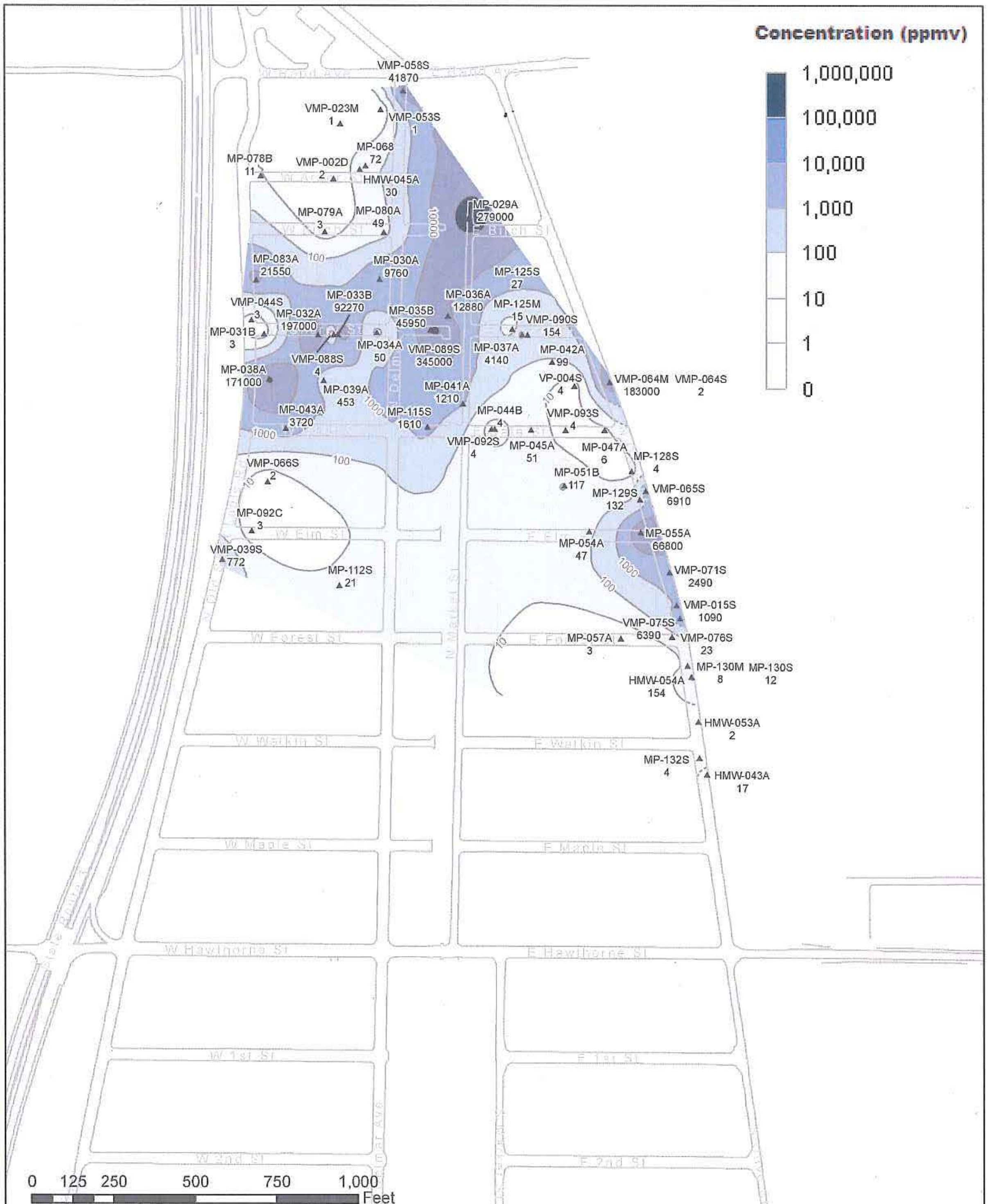
Figure 3	Legend	FID North Olive Stratum September 2009	AECOM
	▲ September Monitoring Location and Value (ppmv) Isoconcentration Contours Manual Contours Streets		Prepared for: Hartford Working Group Hartford, Illinois
	Notes: Based on final data for September 2009 SVE System Effectiveness Monitoring Event.	Data Source: Provided by URS Screening Stratum Revision October 2008 Effectiveness monitoring data processed and analyzed using Environmental Visualization System PRO Version 9.13	Date: October 16, 2009 Project Number: 01007-530



Draft
Work in Progress

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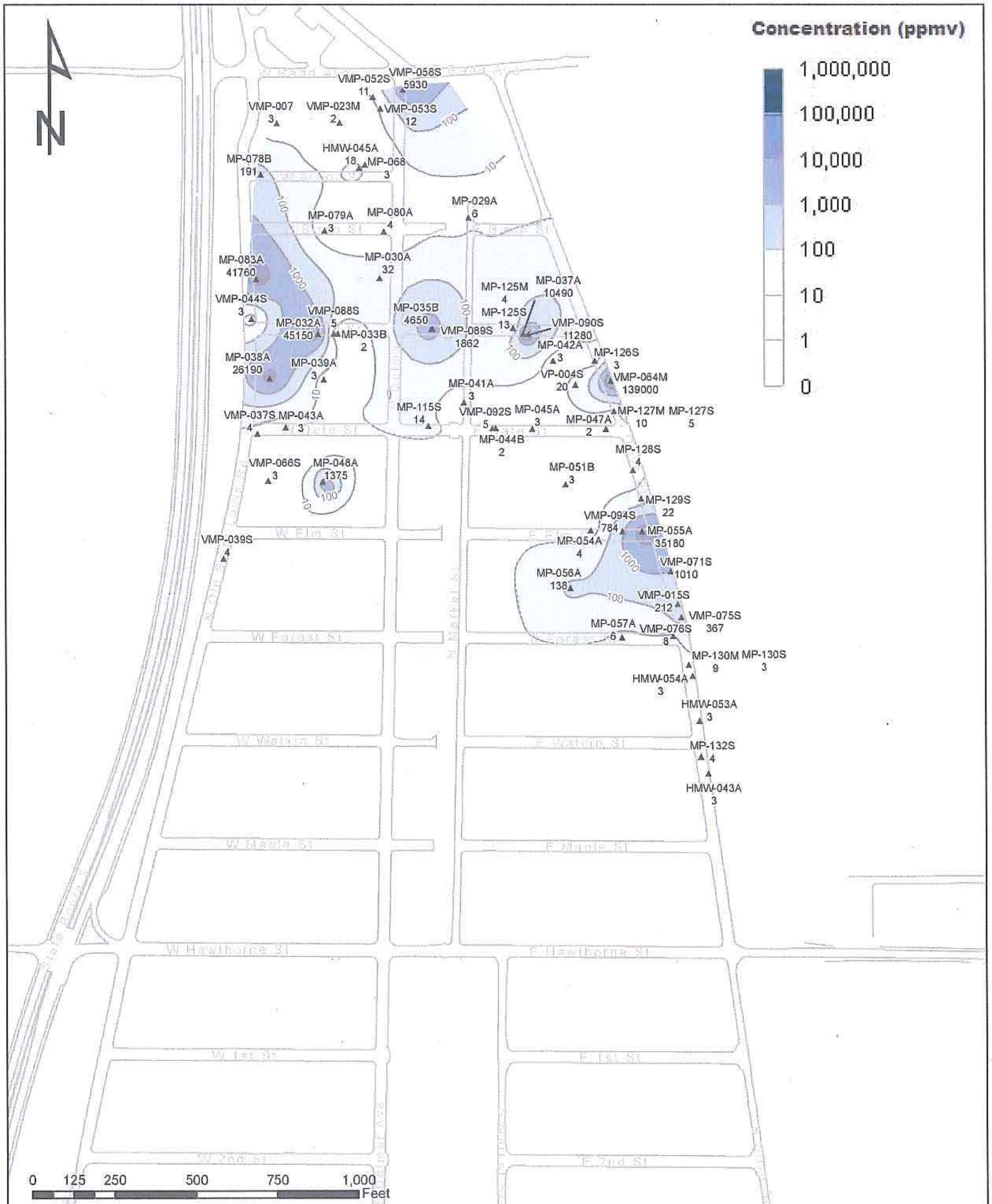
Figure	Legend	FID	AECOM
3	▲ November Monitoring Location and Value (ppmv) Isoconcentration Contours Manual Contours Streets Notes: Based on final data for November 2009 SVE System Effectiveness Monitoring Event.	N Olive Stratum November 2009 Data Source: Provided by URS Screening Stratum Revision October 2008 Effectiveness monitoring data processed and analyzed using Environmental Visualization System PRO Version 9.13	Prepared for: Hartford Working Group Hartford, Illinois Date: December 8, 2009 Project Number: 60141205



Draft
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Figure

3

Legend

- ▲ January Monitoring Location and Value (ppmv)
- Isoconcentration Contours
- Manual Contours
- Streets

Notes:
Based on final data for January 2010
SVE System Effectiveness Monitoring Event.

FID
N Olive Stratum
January 2010

Data Source:
Provided by URS
Screening Stratum Revision October 2008

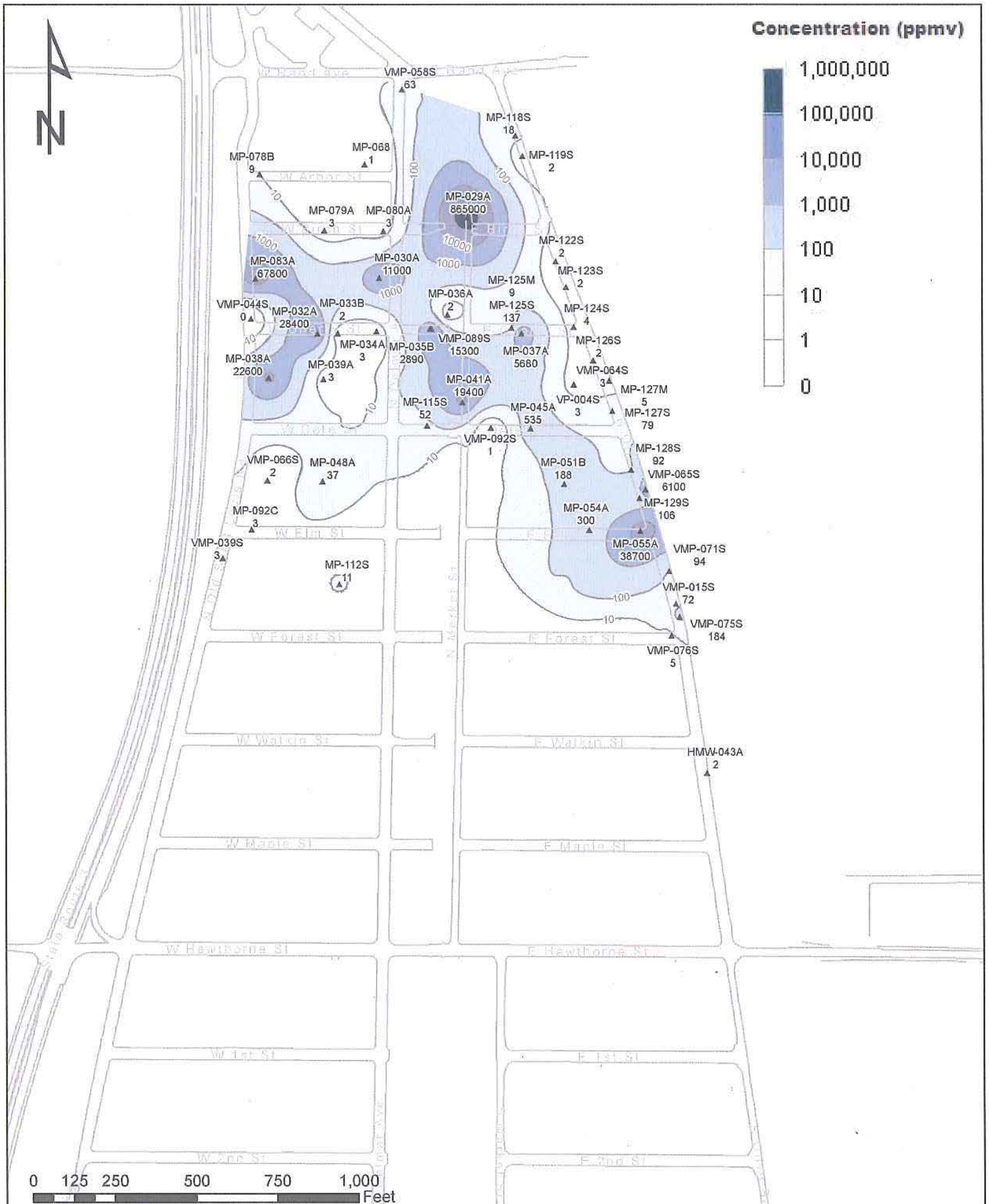
Effectiveness monitoring data processed and analyzed using Environmental Visualization System PRO Version 9.13

AECOM

Prepared for:
Hartford Working Group
Hartford, Illinois

Date: February 23, 2010

Project Number: 60141205



Draft
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Figure 3

Legend

- ▲ February Monitoring Location and Value (ppmv)
- —— Isoconcentration Contours
- ------ Manual Contours
- ······ Streets

Notes:
Based on final data for February 2010
SVE System Effectiveness Monitoring Event.

FID
N Olive Stratum
February 2010

Data Source:
Provided by URS
Screening Stratum Revision October 2008

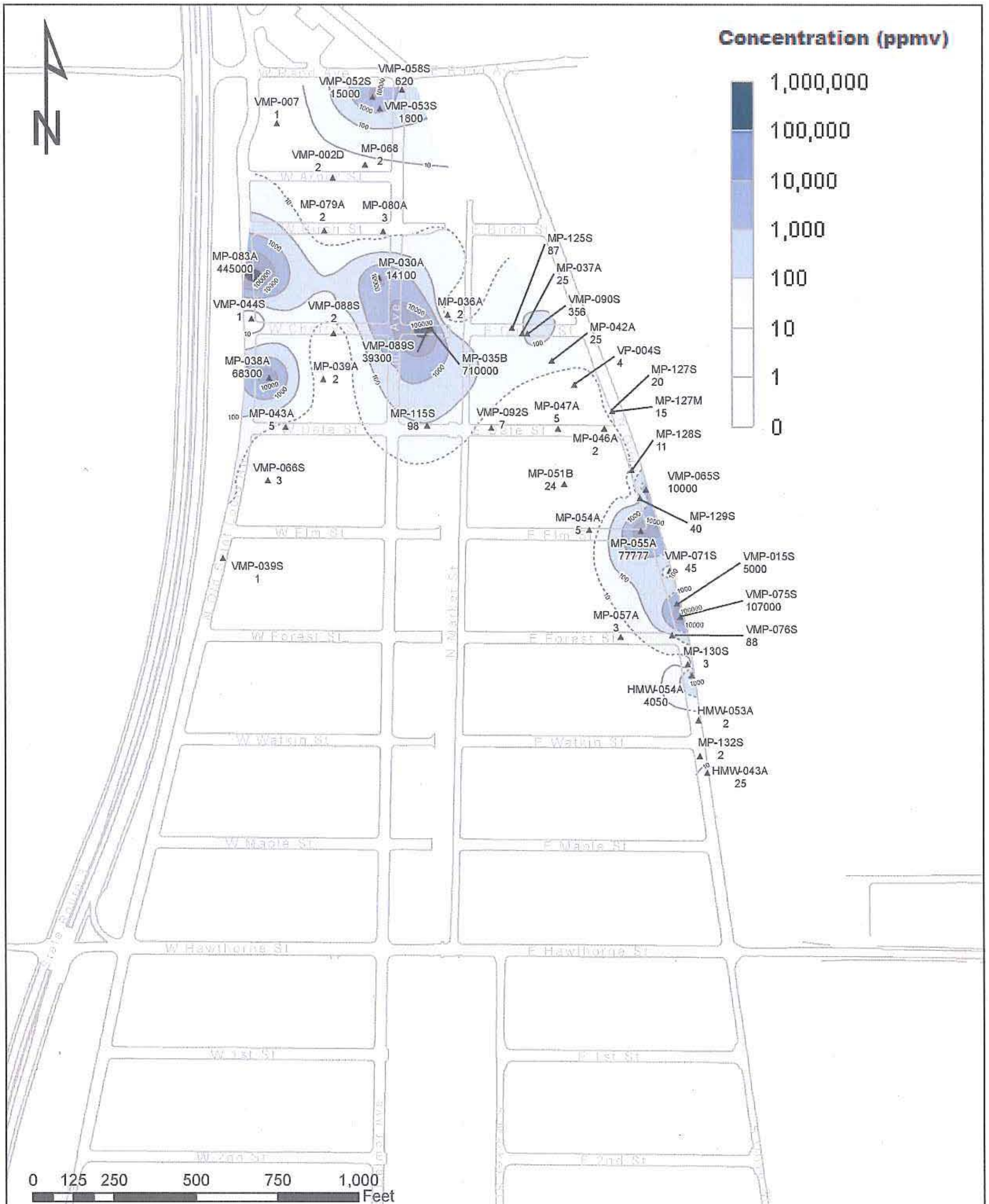
Effectiveness monitoring data processed and analyzed using Environmental Visualization System PRO Version 9.13

AECOM

Prepared for:
Hartford Working Group
Hartford, Illinois

Date: March 18, 2010

Project Number: 60141205



Draft
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Figure	Legend	FID	AECOM
3	▲ June Monitoring Location and Value (ppmv) —— Isoconcentration Contours ······· Manual Contours —— Streets Notes: Based on final data for June 2010 SVE System Effectiveness Monitoring Event.	N Olive Stratum June 2010 Data Source: Provided by URS Screening Stratum Revision October 2008 Effectiveness monitoring data processed and analyzed using Environmental Visualization System PRO Version 9.13	Prepared for: Hartford Working Group Hartford, Illinois Date: July 7, 2010 Project Number: 60141205

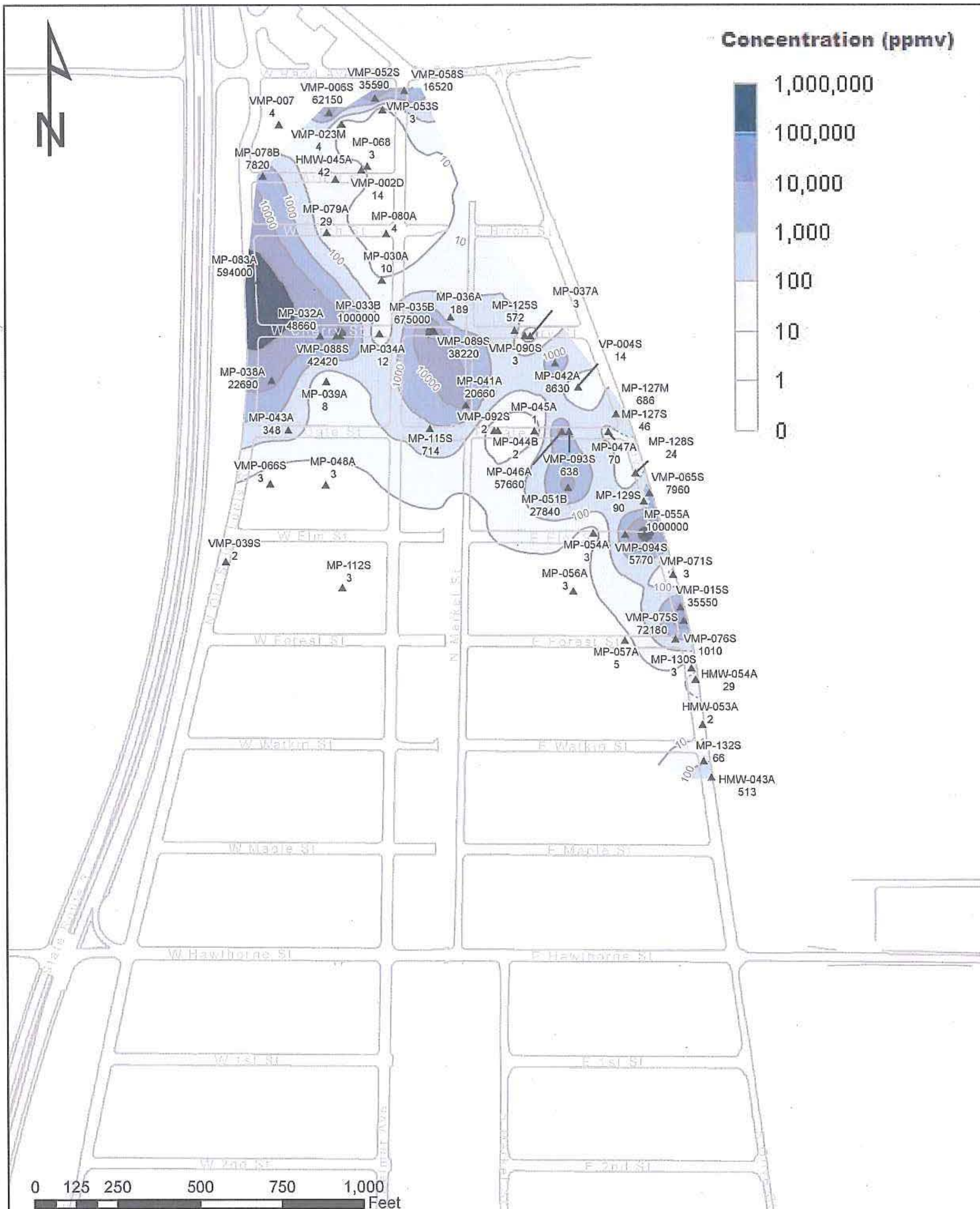

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Figure 3

Legend
- ▲ August Monitoring Location and Value (ppmv)
- Isoconcentration Contours
- Manual Contours
- Streets

Notes:
Based on final data for August 2010
SVE System Effectiveness Monitoring Event

FID
N Olive Stratum
August 2010

Data Source:
Provided by URS
Screening Stratum Revision October 2008

Effectiveness monitoring data processed and analyzed using Environmental Visualization System PRO Version 9.13

AECOM

Prepared for:
Hartford Working Group
Hartford, Illinois

Date: September 13, 2010

Project Number: 60141205

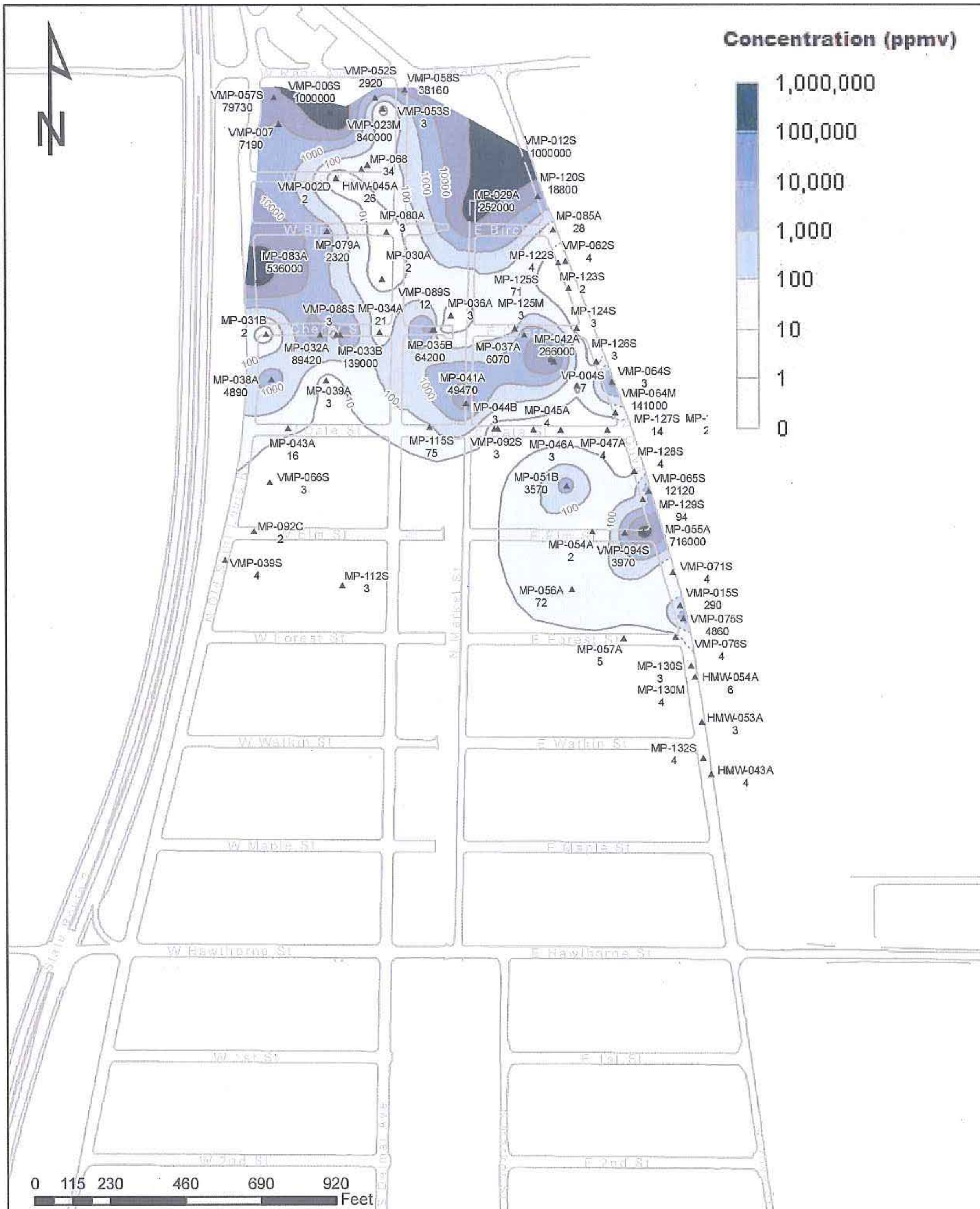

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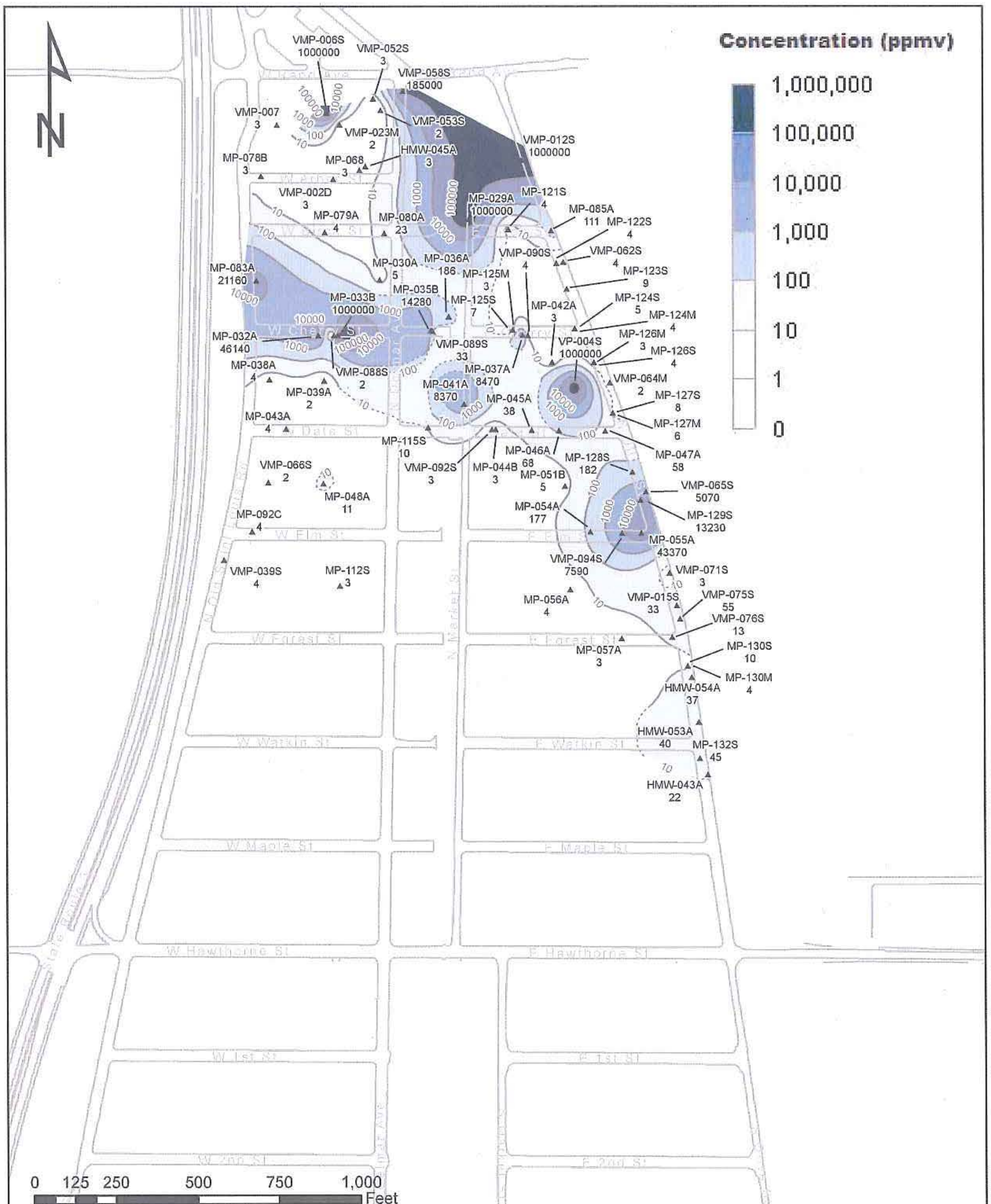
Figure	Legend	FID	AECOM
3	▲ November Monitoring Locations and Value (ppmv) —— Isoconcentration Contours ------- Manual Contours —— Streets Notes: Based on final data for November 2010 SVE System Effectiveness Monitoring Event.	N Olive Stratum November 2010 Data Source: Provided by URS Screening Stratum Revision October 2008 Effectiveness monitoring data processed and analyzed using Environmental Visualization System PRO Version 9.13	Prepared for: Hartford Working Group Hartford, Illinois Date: December 14, 2010 Project Number: 60188657



Draft
Work in Progress

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Figure	Legend	FID	AECOM
3	▲ Monitoring Location and Value (ppmv) Streets Isoconcentration Contours Manually Interpreted Contours Data Source: Provided by URS Screening Stratum Revision October 2008 Effectiveness monitoring data processed and analyzed using Environmental Visualization System PRO Version 9.13	N. Olive Stratum February 2011 Notes: Based on final data for February 2011 SVE System Effectiveness Monitoring Event.	Prepared for: Hartford Working Group Hartford, Illinois Date: March 22, 2011 Project Number: 60188657

FINAL FOR AGENCY REVIEW
SOIL VAPOR EXTRACTION SYSTEM
EFFECTIVENESS ZONE 6 OPTIMIZATION REPORT

HARTFORD PETROLEUM RELEASE SITE

HARTFORD, ILLINOIS

October 26, 2016

APEX OIL COMPANY, INC.

8235 Forsyth Boulevard

St. Louis, Missouri 63105

212 ENVIRONMENTAL CONSULTING, LLC

816 Delta Avenue

Cincinnati, Ohio 45226

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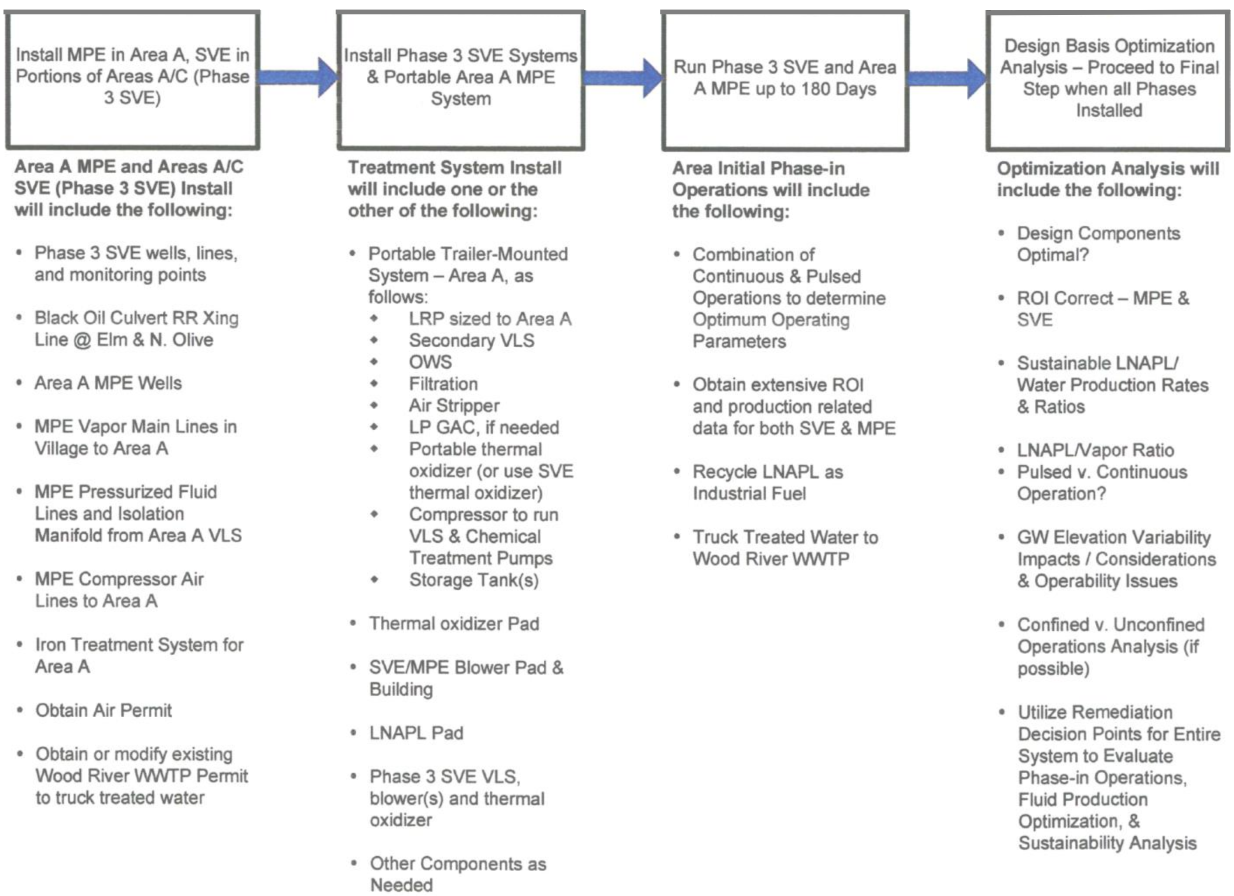
SECTION 1.0
INTRODUCTION

Apex Oil Company, Inc. (Apex) met with the United States Environmental Protection Agency (USEPA) and Illinois Environmental Protection Agency (Illinois EPA) on November 17, 2015 to discuss the progress of remedial alternatives evaluation and implementation at the Hartford Petroleum Release Site (Hartford Site), including those activities described within the *Active LNAPL Recovery System 90% Design Report, The Hartford Area Hydrocarbon Plume Site, Hartford, Illinois* (*90% Design Report*, Clayton 2006). As discussed during the meeting, progress has been made in evaluation and implementation of the remedial alternatives described within the *90% Design Report* (Clayton, et al. 2006), including: (1) expansion of the soil vapor extraction (SVE) system, (2) multiphase extraction (MPE) and dual phase extraction (DPE) pilot testing in Area A (situated along North Olive Avenue as shown on Figure 1), as well as (3) analysis of the design basis for future remedial alternatives. The following flow chart adopted from the *90% Design Report* (Clayton, et al. 2006) outlined the remedial approaches for implementation over the past decade at the Hartford Site.



Adopted from Figure 5-1 (Generalized Implementation Flow Chart) of the *Active LNAPL Recovery System 90% Design Report, The Hartford Area Hydrocarbon Plume Site, Hartford, Illinois* (*90% Design Report*, Clayton 2006)

Pursuant to United States 7th Circuit District Court Chief Judge Herndon's Decision (Docket Number 05-CV-242-DRH) dated July 28, 2008, Apex is required to implement a final remedy at the Hartford Site including activities described within the *90% Design Report* (Clayton, et al. 2006). The proposed design was not considered final (in other words this was not a 100% design), due to several factors including: (1) the complex and heterogeneous lithologic setting, (2) the large and variable light non-aqueous phase liquid (LNAPL) source zones, (3) the significant variability in sustainable LNAPL recovery rates observed during previous short duration LNAPL recovery tests, and (4) the uncertainty in the optimal system configuration and operations within a residential setting. As a result, the *90% Design Report* (Clayton, et al. 2006) envisioned a phased implementation approach, with each step dependent upon testing, evaluation, and analysis prior to full implementation. During the preliminary implementation phase, permanent systems would be used for the SVE portion of the remedy, while portable systems would be utilized for pilot testing of MPE and other remedial alternatives (if appropriate), beginning in Area A of the Hartford Site. It was determined that permanent, fixed remedial systems would be constructed for MPE or other remedial alternatives following completion of the preliminary implementation phase and selection of an optimal remedial approach(s).

USEPA noted in its technical review of the *90% Design Report* (Clayton, et al. 2006) that implementation and operation of an expanded SVE system was relatively straightforward compared to MPE (or other remedial alternatives). In their written comments, USEPA identified that sufficient operational data had been collected to justify expansion of the SVE system (USEPA 2006). Accordingly, USEPA requested that the SVE components of the *90% Design Report* including Phase 3 expansion of the system be fast tracked and performed independent of testing and design of additional remedial technologies.

In the years since submittal of the *90% Design Report* (Clayton, et al. 2006), more than 81 vapor extraction wells have been installed across the Hartford Site as part of the Phase 3 system expansion and other optimization efforts (e.g., SVE Effectiveness Zone 1 Optimization), which is more than half of the SVE wells envisioned within the *90% Design Report* (Clayton, et al. 2006). Specifically, 24 additional extraction wells have been installed in SVE Effectiveness Zone 6 (Zone 6) in the northeast portion of the Hartford Site since 2007. The *90% Design Report* (Clayton, et al. 2006) envisioned installation of 25 extraction wells within shallower permeable strata (referred to as the Rand strata) and 10 additional vapor extraction wells within the deeper, more permeable strata (referred to as the EPA and Main Sand Strata) in Zone 6. As discussed during the November 17, 2015 meeting with the USEPA and Illinois EPA, many of these additional extraction wells installed in Zone 6 (particularly those wells installed in the Rand stratum along North Olive Avenue) have not been operational and have contributed negligibly to mass recovery in this portion of the Hartford Site. These wells have not been operable largely due to occlusion of the well screen with groundwater over time. This occurs despite an extensive effort to install stingers within the extraction wells and recover groundwater via total phase extraction (TPE) instead of operating the wells to solely recover vapors, as originally designed.

1.1. PURPOSE

In an effort to continue to optimize and implement the vapor extraction components of the *90% Design Report* (Clayton, et al. 2006), Apex has conducted additional testing and evaluation of the infrastructure and operations within Zone 6. These activities have focused on defining the geologic, hydrologic, construction, and operational criteria that have contributed to elevated volatile hydrocarbon recovery in specific locations during specific timeframes within this portion of the Hartford Site. Specifically, these activities included:

1. Reevaluation of the three-dimensional (3D) visualization of the geologic setting underlying Zone 6. A detailed 3D visualization analysis of the lithology described during installation of soil borings was prepared and subsequently compared to the generalized 3D stratigraphic interpretation of the geologic setting. These 3D visualization analyses were compared to determine if there are additional geologic factors that may be affecting efforts to recover volatile hydrocarbons in specific locations in Zone 6.
2. Field testing of increased water recovery rates within selected extraction wells screened in the Rand stratum along North Olive Avenue (referred to as an enhanced TPE test) to determine if additional water recovery using stingers (as well as the existing transmission system and treatment infrastructure) would allow for sustained exposure of the well screen and improved vapor recovery.
3. Evaluation of the construction, operation, and maintenance within the existing SVE network within Zone 6 to determine if modification to the existing system and/or installation of additional extraction wells may enhance mass recovery.

1.2. REPORT ORGANIZATION

This report presents the results of the additional testing and evaluation of SVE operations within Zone 6 performed by Apex since February 2016. The remainder of this report is organized as follows:

- **Section 2.0** – Provides a brief background of the Hartford Site focusing on remedial activities performed site-wide as well as within Zone 6.
- **Section 3.0** – Describes the site setting for Zone 6 including comparison of the 3D visualization analyses depicting the underlying geology in this portion of the Hartford Site.
- **Section 4.0** – Summarizes the enhanced TPE test including the methodology, results, and recommendations for future operations.
- **Section 5.0** – Includes an evaluation of the existing SVE well network, construction details, operations, monitoring, and maintenance activities.
- **Section 6.0** – Provides a summary of recommendations for further improving mass recovery in Zone 6.

SECTION 2.0
BACKGROUND

The Village of Hartford is located in Madison County, Illinois on the east bank of the Mississippi River, approximately twelve miles northeast of St. Louis, Missouri. Three refineries were constructed adjacent to the northern portion of the Village of Hartford between 1907 and 1941, the Amoco Oil Refinery (currently British Petroleum facility), the Clark Oil Refinery (currently the Premcor Facility), and the Shell Oil Refinery (currently the ConocoPhillips facility). In addition, a bulk petroleum storage facility was constructed north of the Village of Hartford (currently the Hartford Wood River Terminal Oil Company facility). Refining, storage, and transport of petroleum hydrocarbons continues to be conducted adjacent to the Village of Hartford associated with portions of these refineries and terminal operations. In addition, numerous underground and aboveground petroleum pipelines connect the refineries and terminal to loading and unloading facilities on the Mississippi River. Figure 1 shows the location of the Hartford Site and adjacent facilities. Numerous releases of petroleum hydrocarbons, hereafter referred to as light non-aqueous phase liquids (LNAPL), have been documented within or immediately adjacent to the northern portions of the Village of Hartford.

2.1. INTERIM MEASURES

Interim measures were implemented at the Hartford Site beginning in 1978, and have primarily consisted of LNAPL skimming and soil vapor extraction (SVE). As of 2015, approximately 3.2 million gallons of LNAPL had been recovered with 1.3 million gallons removed via skimming (USEPA 2010, RAM 2013) and an additional 1.9 million gallons as vapor from operation of the SVE system (Illinois EPA 2004, Trihydro 2015). Figure 2 shows the volume of hydrocarbons recovered via skimming and SVE since 1978.

2.1.1. LNAPL SKIMMING

In 1978 and 1979, Clark Oil installed two large diameter groundwater production wells (RW-001 and RW-002) at the Hartford Site for the purpose of skimming LNAPL from the Main Sand stratum. Production well RW-002 was installed in Zone 6. Between 1978 and 1990, LNAPL skimming was performed within these two production wells, with the exception of a period between 1983 and 1984 when operations were temporarily ceased. Approximately 1,162,000 gallons of LNAPL were recovered from these two wells through 1990. Recovery rates of LNAPL during skimming ranged from approximately 1,000 to 29,000 gallons per month (USEPA 2010). It should be noted that skimming was discontinued in 1984 but resumed between 1985 and 1990, although detailed LNAPL recovery records are not available, the total volume removed over that timeframe was reportedly more than 400,000 gallons (USEPA 2010). There are no available records of skimming being performed in the production wells between 1991 and 1993. However, a third production well (RW-003) was installed in Zone 6 by Premcor in 1993. From January 1994 through September 2002, Premcor reportedly recovered 82,700 gallons of LNAPL from the three production wells (USEPA 2010). Between late 2002 and 2004 skimming does not appear to have been conducted within the production wells installed in the Village of Hartford.

Beginning in 2004, the Hartford Working Group (a consortium of oil companies including Premcor, Shell, British Petroleum, and Sinclair Oil Corporation) began managing interim measures and installed three additional production wells (RW-004, RW-004A, and RW-005) in Zone 6, as depicted on Figure 1. Approximately 18,000 gallons of LNAPL were recovered via skimming activities within the Main Sand stratum between 2004 and 2009. During this time, the Hartford Working Group also conducted several pilot tests to evaluate potential remedial technologies including multiphase extraction and dual phase extraction. An additional 12,000 gallons of LNAPL were recovered as part of pilot testing these two remedial technologies.

In March 2009, routine operations, maintenance, and monitoring (OMM) of the interim measures at the Hartford Site were transferred to Apex. Apex conducted LNAPL skimming at two of the recovery wells (RW-002 and RW-004A) through December 2010 and recovered 15,000 gallons of LNAPL. In addition, Apex conducted LNAPL skimming within the groundwater and multipurpose monitoring network beginning in 2009 and recovered an additional 25,000 gallons of LNAPL through the end of 2012.

2.1.2. SOIL VAPOR EXTRACTION

An SVE system was installed and operated by Clark Oil & Refining Corporation (now Premcor) in 1992 and consisted of 12 vapor control boreholes, two blowers, and a single thermal treatment oxidizer. Beginning in 2005, the Hartford Working Group replaced the original SVE system in three phases. The current SVE system consists of a network of approximately 118 vapor extraction wells connected through a series of piping and valves to a single 12-inch pipe (referred to as the Main Header) that extends to the east beneath the railroad right-of-way to a series of four thermal oxidizers located on the Premcor Facility. Figure 3 shows the general location of the SVE extraction wells and piping, as well as the SVE Effectiveness Zones (Zones 1 through 6) established for the purpose of evaluating the system performance.

As shown on Figure 2, approximately 930,000 equivalent gallons of volatile petroleum hydrocarbons were recovered via the initial SVE system between 1992 and 2004. Approximately 1,000,000 equivalent gallons of volatile petroleum hydrocarbons have been recovered via the current SVE system between May 2005 and December 2015. Vapor recovery has not reached asymptotic conditions, as the highest daily recovery occurred in late 2012 due to sustained low groundwater elevations over several months and focused efforts to remove vapors during these temporary low water table conditions.

2.1.2.1. EFFECTIVENESS ZONE 6

As depicted on Figure 3, there are currently 28 vapor extraction wells installed in Zone 6, with 18 of the wells located along North Olive Avenue and the remainder installed along East Birch Street, East Cherry Street, as well as the connecting alley. Three lines of section (Figure 4) were prepared for Zone 6 to depict the construction details for the extraction wells relative to the generalized stratigraphy, historical LNAPL occurrence, and typical perched groundwater levels in nearby monitoring locations. Cross sections depicting the generalized stratigraphy and historical LNAPL occurrence were previously presented within the *LNAPL Component to the Conceptual Site Model, Hartford Petroleum Release Site Hartford, Illinois* (*LNAPL Component to the CSM*, Trihydro 2014); additionally, cross sections showing the construction details for the SVE wells located in Zone 6 were previously presented within the *Final Vapor Collection System Operation, Maintenance, and Monitoring Plan, Hartford Petroleum Release Site, Hartford, Illinois* (*Final Vapor Collection System OMM Plan*, Trihydro 2015). As shown on Figure 5, twelve of the extraction wells in Zone 6 are screened within the shallowest permeable stratum (referred to as the North Olive stratum) and sixteen wells are screened within the underlying permeable unit (referred to as the Rand stratum). The majority of the SVE wells have been retrofitted with a small diameter (0.5- to 1.5-inch) stinger extending to the top of the perched water within the well, which allows for simultaneous extraction of groundwater and soil vapor (referred to as TPE). Construction details for each of the SVE wells installed within Zone 6 are included in Table 1.

SVE operational details recorded over the past year for the extraction wells installed within Zone 6 are provided in Table 2. A summary of the percent operation for each of the extraction wells (expressed as a percentage of the time the well was operating) between October 2015 and March 2016 is provided on Figure 6. The vapor extraction wells installed within the North Olive stratum have been largely operable over the past year (as well as previous years). However, extraction wells installed within the Rand stratum have not been operable due to the well screen being occluded with groundwater nearly continuously since installation. The following bullets summarize the operations for extraction wells situated in Zone 6 during the past year.

- North Olive stratum
    - Of the 12 wells installed within the North Olive stratum, all but 3 have been operable.
    - Wells HSVE-001S, HSVE-001D, and HSVE-030S have been inoperable due to silt and water continuously blocking the transmission line connecting these wells to the remainder of the system.
    - Approximately 85% of the mass recovered within Zone 6 was attributed to the extraction wells screened within the North Olive stratum
    - Approximately 60% of the mass recovered within Zone 6 was attributed to operation a single extraction well, well HSVE-099.
- Rand stratum
    - Three of the 16 wells screened within the Rand stratum have been operable during the last year including wells HSVE-071, HSVE-072, and HSVE-076.
    - Well HSVE-076, located at the southern limit of Zone 6, is the only operable well screened in the Rand stratum installed along North Olive Avenue. This well has been operable 12.1% of the time.
    - Well HSVE-030D has been continuously inoperable due to silt and water blocking the transmission line connecting this well to the remainder of the system.

SITE SETTING

This section presents a summary of the setting beneath Zone 6 of the Hartford Site including a discussion of the geology, hydrogeology, and distribution of petroleum hydrocarbons in the subsurface. Of particular focus is the comparison between the previously described generalized stratigraphic interpretation of the geology and the detailed lithologic interpretation that was prepared using the lithologic logs generated during installation of soil borings in Zone 6. A detailed understanding of the site setting is useful in understanding the current operations and potential optimization of the vapor collection system.

3.1. GEOLOGIC SETTING

The Hartford Site is located along the historical edges of the Mississippi and Missouri River flood plains within a shallow valley approximately 30 miles long and 11 miles across at its widest point, and underlain by more than 100 feet of unconsolidated deposits created by alluvial and glacial processes during the Pleistocene period. Over the last 125,000 years, the Mississippi River has changed its course frequently resulting in deposition of sediments with widely-varying grain size across a broad area creating a highly heterogeneous unconsolidated stratigraphy (USEPA 2010). As a result, the lithology beneath the Hartford Site consists of alternating alluvial deposits of predominantly clay and silt overlying regionally extensive sand deposits locally referred to as the Main Sand stratum.

3.1.1. GENERALIZED STRATIGRAPHIC INTERPRETATION

The Main Sand stratum consists of alluvial sands and coarse grained glacial outwash that ranges from 80 to 100 feet in thickness. The alluvial deposits overlying the Main Sand, while interbedded and generally discontinuous, have been described by others in terms of a simplified stratigraphic sequence (Clayton 2005, Clayton, et al. 2006). The more permeable units have been identified (in descending order with respect to depth) as the North Olive, the Rand, and the EPA hydrostratigraphic units. These permeable zones are bounded by discontinuous clay deposits that have been labeled (in descending order with respect to depth) as the A, B, C, and D Clay.

The A Clay is continuously present beneath the Hartford Site, with the exception of areas where it has been removed as part of construction activities. The B and C Clay are highly discontinuous and of limited aerial extent. The B and C Clay define the extent of the North Olive and Rand hydrostratigraphic units, respectively. The North Olive and Rand strata laterally grade into and are hydraulically connected with the Main Sand (and Main Silt where present under the western and southwestern portions of the Hartford Site), where the B and C Clay are absent.

The D Clay underlies and defines the limits of the EPA stratum. The D Clay could be considered a discontinuous lens within the Main Sand stratum based on its relative thickness (between approximately 2 and 7 feet) and limited extent (only present in the northeastern portion of the Hartford Site). The EPA stratum grades laterally into the Main Sand to the south of a southwesterly trending line extending from the intersection of Old St. Louis Road and North Delmar Avenue to just north of the intersection of East Date Street and North Olive Street. Along this boundary, the EPA and Main Sand are hydraulically connected with flow in the EPA stratum towards the southwest.

A 3D visualization of the generalized stratigraphic interpretation was previously prepared as part of the *LNAPL Component to the CSM* (Trihydro 2014). This 3D visualization incorporated the stratigraphic interpretations from 379 soil borings summarized within the *LNAPL Active Recovery System Conceptual Site Model, The Hartford Area Hydrocarbon Plume Site* (*LNAPL Active Recovery System CSM,* Clayton 2005) and maintained within an Earthsoft EQuIS™ SQL database by the Hartford Working Group. The stratigraphic interpretation was verified using detailed lithologic descriptions recorded via Cone Penetration Testing performed within more than 100 borings across the Hartford Site.

Leapfrog Hydro 4.0™ (Leapfrog), a specialized visualization software, was used to integrate the generalized stratigraphic interpretations into a 3D mesh, with zones between data points using all adjacent borings for interpolation. The stratigraphic units (e.g., A-Clay, North Olive stratum, etc.) were modeled as geologic layers, configured with horizontal reference planes. Within Leapfrog, the lithologic contact surfaces were ordered chronologically to achieve the following layering of output volumes/strata (from shallowest to deepest) as historically described by the Hartford Working Group within the *LNAPL Active Recovery System CSM* (Clayton 2005):

- A-Clay
- North Olive
- B-Clay
- Rand
- C-Clay
- EPA
- D-Clay, and
- Main Sand

Cross sections depicting the generalized stratigraphic interpretation of the geology underlying Zone 6 exported from Leapfrog are provided on Figure 7 (section along North Olive Avenue) and Figure 8 (section along North Market Street). In addition, a 3D isopach map of the generalized stratigraphy showing the clay, silt, and sand units is included on Figure 9.

3.1.2. DETAILED LITHOLOGIC INTERPRETATION

At the urging of USEPA and its technical advisers, 212 Environmental Consulting, LLC (212 Environmental) developed a more detailed 3D visualization of the Zone 6 lithology using geologist logs generated during earlier soil borings within Zone 6. Lithologic data (i.e., data specifying the start and end depth of a particular soil type) from 48 unique borings were used to develop the detailed 3D visualization. The lithology described by the geologist was assigned a United Soil Classification System (USCS) soil type, which was recorded on the log generated for each soil boring. The USCS soil types were converted to a numerical value based on grain size and sorting as follows:

Soil Description	USCS Soil Type	Numeric Value
High plasticity clays, fat clays	CH	1
Low to medium plasticity clays, lean clays	CL	2
Low to medium plasticity clays with low plasticity silts	CL/ML	3
High plasticity silts with high plasticity clays	MH/CH	4
Low plasticity silts with high plasticity clays	ML/CH	5
Low plasticity silts with low to medium plasticity clays	ML/CL	6
Low plasticity silts	ML	7
Low plasticity silts with silty sands	ML/SM	8
Silty sands with low plasticity silts	SM/ML	9
Clayey sands, sand-clay mixtures	SC	10
Clayey sands with silty sands	SC/SM	11
Silty sands with clayey sands	SM/SC	12
Silty sands, sand-silt mixtures	SM	13
Silty sands with poorly graded sands or gravelly sands	SM/SP	14
Poorly graded sands or gravelly sands	SP	15
Well graded sands or gravelly sands	SW	16

It should be noted that there are many additional USCS soil types and combined soil types than those listed on this table and incorporated into the 3D visualization. Only those USCS symbols and combined symbol types identified on the lithologic logs for the 48 borings installed in northern portions of Zone 6 were used to create the 3D visualization.

The numerical values assigned for each vertical lithologic interval were then incorporated into Leapfrog and modeled using a linear interpolant to create an implicit model of the detailed lithology. Interpolation is a method that produces an estimate or "interpolated value" between known data points. The interpolant is used to assign a weighting to the known data based on the distance away from the unknown value or in this case the lithology. Samples that are assigned lower weighting by the interpolant have a stronger effect on the estimated value than those that are given higher weighting. The linear interpolant assumes that data closer to the unknown value are more important than data that is further away (Leapfrog 2013). Similar to an inverse distance weighting algorithm, Leapfrog uses a Radial Basis Function (RBF) for interpolation, with the interpolation being symmetrical for a sphere around a given data point and a "spline function" for smoothing between data points. The primary non-default user input for this software algorithm is the horizontal to vertical anisotropy (H:V), which was set to 100:1. A detailed summary of the Leapfrog 3D implicit model inputs and assumptions are provided in Appendix A.

The lateral limits of the 3D model were clipped to an area extending 50 feet beyond the lateral extent of the borings in the four cardinal directions. Specifically, the model extended from East Cherry Street to approximately 140 feet south of East Rand Street, and approximately 40 feet west of North Market Avenue to approximately 5 feet east of intersection of North Olive Avenue and East Cherry Street.

Cross sections depicting 212 Environmental' s more detailed lithologic interpretation were compared to the generalized stratigraphic interpretation on Figure 7 (section along North Olive Avenue) and Figure 8 (section along North Market Street). In addition, 3D isopachs showing the major soil types (clays, silts, and sands) beneath Zone 6, as depicted in the detailed lithologic interpretation are included on Figure 9. The detailed lithologic interpretation illustrates the highly heterogeneous and interbedded nature of the reworked alluvial and glacial sediments in the upper 40 feet of the subsurface beneath Zone 6. In particular, this interpretation illustrates the discontinuous nature of clay lenses deeper than 10 feet below ground surface (ft-bgs). These clays are shown as continuous units within the generalized stratigraphic interpretation but are more definitively represented as isolated lenses within the detailed lithologic interpretation. Furthermore, the detailed lithologic interpretation depicts a coarsening sequence from the continuous clay layer present in the shallowest portions of the subsurface (referred to as the A clay) down to the regionally extensive sand deposits at depth (referred to as the Main Sand stratum) that cannot be inferred from the general stratigraphic interpretation of the geology beneath Zone 6.

The detailed lithologic interpretation was verified using detailed Cone Penetration Testing results from seven borings installed in Zone 6, as depicted on Figures 7 and 8. While the detailed lithologic interpretation depicts a more nuanced and discontinuous setting within the upper 40 feet of the subsurface compared to the generalized stratigraphic interpretation, it is not any more accurate in showing the actual geology, as reported within the borings installed via Cone Penetration Testing. Although the model provides a better sense of the distribution of glaciofluvial deposits in the shallower portions of the subsurface, detailed analyses using existing lithologic logs and additional soil borings will be more useful and practical when designing new recovery wells at the Hartford Site, although more detailed lithologic modeling may be considered where conditions indicate the importance of this activity to the design, installation, and construction of additional wells.

3.2. GROUNDWATER OCCURRENCE

There are four water bearing zones, or hydrostratigraphic units, located beneath Zone 6. Two of these are shallow hydrostratigraphic units (the North Olive and Rand) that are generally present within the coarser grained silt and fine sand deposits underlain by clay lenses. These shallow water-bearing zones are generally discontinuous. Groundwater is also present in the more permeable sands that compose the EPA and Main Sand strata. Groundwater present in these hydrostratigraphic units is part of an extensive aquifer system commonly referred to as the American Bottoms aquifer.

3.2.1. NORTH OLIVE STRATUM

Groundwater in the North Olive stratum generally occurs in isolated areas that are temporarily perched on the surface of the B Clay before draining into underlying strata. Fluid level gauging is performed quarterly within 20 locations screened within the North Olive stratum in Zone 6. Groundwater elevations reported in these monitoring locations during high (Second Quarter 2014) and low (Fourth Quarter 2013) water table events are shown on Figures 10. The majority of the monitoring locations screened within this shallowest permeable unit in Zone 6 were dry during both high and low water table events. Within the five monitoring locations reported with groundwater in Zone 6, elevations were reported between 412 and 420 feet above mean sea level (ft-amsl). Groundwater elevations within these monitoring locations varied by less than a foot (e.g., HMW-013) to more than three feet (e.g., HMW-048A) between high and low water table events. Precipitation is the dominant recharge mechanism influencing groundwater elevations in the North Olive stratum (Trihydro 2016).

3.2.2. RAND STRATUM

The Rand stratum is defined by the presence of the underlying C Clay, such that the Rand is absent if the underlying C Clay is absent. Quarterly fluid level gauging is performed within 22 locations screened in the Rand stratum. Figure 11 depicts groundwater elevations within the Rand stratum during high (Second Quarter 2014) and low (Fourth Quarter 2013) water table conditions. As with the North Olive stratum, groundwater in the Rand stratum is largely perched and is spatially, as well as temporally variable. However, within Zone 6 the deeper silts and sands that make up the Rand stratum generally remain saturated throughout the year (with only two monitoring locations reported as dry during high water table conditions and four during low water table conditions). Groundwater elevations are generally between 402 and 420 ft-amsl in the Rand stratum beneath Zone 6, with elevations in a monitoring location varying by less than a foot (e.g., MP-042B) to more than 8 feet (e.g., HMW-048B) between high and low water table events. River stage in the Mississippi River does not appear to significantly affect groundwater elevations within the Rand stratum, except under extremely high river stage conditions. Precipitation appears to be the dominant recharge mechanism within the Rand, similar to the North Olive stratum (Trihydro 2016).

3.2.3. MAIN SAND AND EPA STRATA

The EPA and Main Sand strata underlie the C-clay and are separated by the D-clay. The D Clay could be considered a thin lens within the Main Sand stratum and groundwater within the EPA stratum are hydraulically connected with the Main Sand stratum. The D-clay and EPA stratum are only observed in Zone 6 of the Hartford Site.

The natural groundwater flow in the Main Sand stratum has been altered beneath the Hartford Site by pumping on the BP (approximately 1,225 gallons per minute), Phillips66 (more than 6,000 gallons per minute along the river dock and 3,000 gallons per minute on the refinery), and Premcor (approximately 300 gallons per minute) facilities. The groundwater flow direction in the Main Sand is also influenced by the stage of the Mississippi River. Since the river stage varies by more than 20 feet during a year, the groundwater conditions fluctuate repeatedly between unconfined and confined conditions.

Figure 12 depicts potentiometric surface maps for the Main Sand stratum based on quarterly fluid level measurements generated during high (Second Quarter 2014) and low (Fourth Quarter 2013) water table conditions. During low water table conditions (Fourth Quarter 2013), groundwater flow is generally towards the west across most of Zone 6. When the water table is seasonally high (Second Quarter 2014), groundwater flow within the Main Sand stratum is generally towards the north and northeast.

3.3. LNAPL OCCURRENCE

As shown on Figure 5, mid and light range LNAPL were observed within each of the hydro-stratigraphic units beneath Zone 6 via laser induced fluorescence (LIF) during an assessment performed using the Rapid Optical Screening Tool (ROST™) between 2004 and 2005 at the Hartford Site. The fluorescence results from two of the ROST™ borings installed in Zone 6 (HROST-004 and HROST-030) were compared to the results from two collocated Ultraviolet Optical Screening Tool (UVOST™) borings installed in 2013 (HUVOST-004 and HUVOST-030). Figures 13 and 14 present the LIF results recorded in 2004 and 2005 as mirror images to the LIF results from 2013. A significant decrease in the LIF response was observed within the North Olive stratum (between 7 and 15 ft-bgs) in collocated boring HROST/HUVOST-004 and in the Rand stratum (between 17 and 25 ft-bgs) in collocated boring HROST/HUVOST-030. Temporal changes in the vertical thickness and maximum fluorescence response within a location between 2004 and 2013 may indicate preferential depletion of the smear zone due to a combination of interim measures, redistribution due to fluctuating groundwater elevations, and natural smear zone depletion processes. However, it should be noted that the thickness and maximum fluorescence response was generally higher in the Rand (between 20 and 29 ft-bgs), EPA (between 31 and 40 ft-bgs), and Main Sand (between 43 and 50 ft-bgs) stratum in collocated boring HROST/HUVOST-004 suggesting that these processes are having little effect on the LNAPL smear zone in the northeastern most portion of Zone 6, where perched water remains present in the shallow silts and fine sands that makeup the North Olive and the Rand Stratum throughout the year.

Table 3 presents a summary of fluid levels measured in locations screened in the shallow hydrostratigraphic units (North Olive and Rand strata) that contained LNAPL at some point over a two-year interval between the third quarter of 2013 and the third quarter of 2015. Residual LNAPL was only reported in a single monitoring location screened in the North Olive stratum (MP-108B) over this timeframe. The maximum LNAPL thickness was reported at 0.31 feet in May 2014 and thicknesses have been decreasing since then. LNAPL was measured in four monitoring locations in Zone 6 that are screened in the Rand stratum (including well HMW-048B and monitoring points MP-

009D, MP-029B, and MP-041B). LNAPL was generally measured during unconfined conditions and only exceeded 1.0-foot thickness in October 2013 in multipurpose monitoring point MP-009D.

Table 4 presents a summary of fluid levels measured in locations screened in the deeper more permeable hydrostratigraphic units (EPA and Main Sand strata) that were reported with a LNAPL thicknesses greater than 4.0-feet over a two-year interval between the third quarter of 2013 and the third quarter of 2015. This table also identifies the depth to the bottom of the overlying confining unit for comparison to the depth of the LNAPL. As shown in this table, the actual LNAPL thicknesses within a monitoring location were typically less than two feet under unconfined conditions, and generally decreased as wells transitioned into highly unconfined conditions (defined to occur when the depth to LNAPL was more than four feet below the bottom of the confining unit). Apparent LNAPL thicknesses increased significantly as conditions became confined, and were even more exaggerated when highly confined (defined to occur when the depth to LNAPL was more than four feet above the bottom of the confining unit). Highly unconfined conditions were observed in the first quarter 2014 and first quarter 2015, while highly confined conditions were observed during the third quarter 2015. Between April and June 2015, more than 14.5 inches of rainfall occurred in the Village of Hartford resulting in a rapid increase in the Mississippi River stage and groundwater elevations within the deeper hydrostratigraphic units.

The thickness of LNAPL within a location is strongly correlated to whether LNAPL is confined or unconfined. The apparent LNAPL thickness becomes exaggerated when the LNAPL elevation is above the contact with the overlying clay. During confining conditions (created when LNAPL within the stratum intercepts and is forced against overlying finer-grained clay), hydrostatic forces drive LNAPL into wells that behave essentially as pressure relief points. When this occurs the top elevation of the LNAPL in a monitoring well will be higher than the base of the confining unit since it is under hydrostatic pressure resulting in an exaggerated (referred to as apparent) LNAPL thickness. When LNAPL is confined in a well, the initial mass present within the casing is recoverable; however, recovery of additional mobile LNAPL is minimal since much of the mass is trapped underneath the water table. Pilot testing of LNAPL recovery using multiphase and dual phase approaches under confining conditions was previously performed in Area A of the Hartford Site and resulted in the removal of minimal LNAPL and/or volatile hydrocarbons (WSP 2012).

3.4. DISSOLVED PHASE CONSTITUENTS

Groundwater sampling and analysis for constituents of concern has been conducted within select monitoring locations screened in the shallow and deeper strata on an annual basis in accordance with the *Final Dissolved Phase Investigation Work Plan, Hartford Petroleum Release Site, Hartford, Illinois* (Trihydro 2013). Since 2013, groundwater samples have been collected for laboratory analysis from two monitoring locations screened within the North Olive stratum (HMW-048A and MP-085A), two monitoring locations screened within the Rand stratum (MP-042B and MP-085B), and one monitoring location (MP-085C) screened within the EPA stratum. While several other locations were targeted to be sampled in Zone 6 over this two-year interval, in many cases attempts to collect groundwater samples were not possible within the shallow strata as there was not sufficient groundwater yield or within the deeper strata due to the presence of LNAPL. Table 5 presents a summary of the dissolved phase results for the constituents of concern (benzene, ethylbenzene, toluene, total xylenes, methyl tert-butyl ether, dissolved arsenic, and dissolved lead) for groundwater samples collected between the third quarter of 2013 and the third quarter of 2015. The dissolved phase results are variable beneath Zone 6, and likely depend on the proximity of the monitoring location to a LNAPL source. The concentration of the dissolved phase constituents of concern were highest in the North Olive stratum in the northeast-most portion of Zone 6 within well HMW-048A and were lowest (reported as non-detect above the laboratory detection limits) in the central portions of Zone 6 along North Olive Avenue (monitoring points MP-085A and MP-085B).

Dissolved phase benzene degradation trends have been prepared for three monitoring locations in Zone 6 including monitoring well HMW-048A screened in the North Olive stratum (Figure 15), monitoring point MP-042B screened in the Rand stratum (Figure 16), and monitoring point MP-085C screened in the EPA stratum (Figure 17). Benzene was selected as it represents the constituent with the greatest potential risk to receptors when comparing the ratio of the constituent concentration measured in groundwater samples to risk based screening limits. Despite the limited effectiveness of vapor recovery within the northeast-most portion of Zone 6, dissolved benzene concentrations in samples collected from well HMW-048A have decreased by more than an order of magnitude since early 2005. Decreasing dissolved phase benzene concentration trends can also be observed in samples collected from monitoring points MP-042B and MP-085C screened in the Rand and EPA strata, respectively.

3.5. VAPOR PHASE CONSTITUENTS

Routine SVE effectiveness monitoring is performed quarterly within the multipurpose monitoring points and nested soil vapor probes installed in Zone 6 in accordance with the *Effectiveness Monitoring Plan, Hartford Hydrocarbon Plume Site, Hartford, Illinois* (*Effectiveness Monitoring Plan,* URS 2014). Activities performed during the quarterly effectiveness monitoring events includes measuring the static pressure, conducting pneumatic tests, and gauging fluid levels within select monitoring locations. In addition, soil vapor samples are collected and field screened for total volatile petroleum hydrocarbons, oxygen, carbon dioxide, methane, and lower explosive limits. Results from the SVE effectiveness monitoring performed between the second quarter 2015 and first quarter 2016 are provided on Table 6.

Routine effectiveness monitoring within Zone 6 is predominantly performed within the monitoring points and nested vapor monitoring probes installed within the North Olive stratum. The monitoring probes and monitoring points installed within the deeper stratum in Zone 6 tend to be occluded with groundwater throughout the year and vapor samples cannot be collected for screening purposes.

Similar to the dissolved phase, total volatile petroleum hydrocarbon concentrations are variable beneath Zone 6, and likely depend on the proximity of the monitoring location to a LNAPL source. As shown on Figure 18, TVPH concentrations were highest in the North Olive stratum along the northern portions of North Olive Street and at the intersection of East Birch and North Market Streets. Elevated total volatile petroleum hydrocarbons in the southeast-most portion of Zone 6 (along North Olive Street) are attributed to elevated concentrations measured in monitoring point MP-127D screened in the Rand stratum. Reduced oxygen and elevated carbon dioxide concentrations are generally observed in soil vapor collected at locations with elevated total volatile hydrocarbons concentrations. These fixed gas results suggest that aerobic biodegradation of volatile petroleum hydrocarbons is occurring within the shallow subsurface beneath the Hartford Site.

SECTION 4.0
ENHANCED TOTAL PHASE EXTRACTION TEST

An enhanced TPE test was conducted between March 1 and March 11, 2016, within three extraction wells installed in the Rand stratum along North Olive Avenue within Zone 6. The enhanced TPE test was performed to determine if increasing water recovery using existing SVE wells and infrastructure would result in (1) exposure of the screen in the operating wells (2) sustained unsaturated conditions within the extraction wells and nearby monitoring locations, and (3) increased mass removal rates for petroleum hydrocarbons. To optimize the likelihood of additional recovery, the enhanced TPE test was performed when groundwater elevations within the Rand stratum were below trigger levels in three of the five trigger monitoring locations described in the *Final Vapor Collection System OMM Plan* (Trihydro 2015).

As discussed in Section 2.1.2.1, extraction wells installed within the North Olive stratum have been largely operable in Zone 6, whereas wells installed within the deeper Rand stratum are largely inoperable due to the well screens being occluded with groundwater throughout the year (Figure 5). As described in Section 3.3, residual LNAPL within the North Olive stratum has been largely depleted via SVE and natural smear zone depletion processes, whereas, LNAPL remains present in the Rand stratum, as well as the deeper, more permeable Main Sand stratum beneath Zone 6. Therefore, it was hypothesized that increased water production rates within the wells screened in the Rand stratum could result in improved mass recovery rates.

The vapor extraction network in Zone 6 was evaluated to determine which wells would be best suited for the enhanced TPE test. Wells installed beyond North Olive Avenue were eliminated since these wells have higher operable rates (HSVE-071 and HSVE-072) or have not been operated due to potential blockages within the transmission lines connecting the well to the other portions of the vapor collection and treatment systems (HSVE-030D). Therefore, extraction wells HSVE-057, HSVE-059, and HSVE-060, screened in the Rand stratum along North Olive Avenue (Figure 3), were selected for the enhanced TPE test. These three wells were selected based on the following criteria:

- The wells are proximal to one another and screened entirely within the Rand stratum (i.e., do not appear to have a screen interval that extends into the overlying B clay)
- These wells have remained inoperable due to occlusion of the screen with groundwater
- These three extraction wells are installed within or adjacent to LNAPL source zones based on LIF, dissolved phase, and vapor phase monitoring results (Section 3.0)

The applicability of the enhanced TPE test is limited to extraction wells screened within the Rand stratum in Zone 6 (primarily along North Olive Avenue). Any observations or recommendations stemming from this test are limited to Zone 6. In no way was this test designed to evaluate the usefulness of TPE within other portions of the Hartford Site. It should be noted that TPE is already successfully implemented within numerous wells in the vapor collection system, specifically TPE has been employed within 59 operating wells over the last two years.

4.1. METHODS

Prior to conducting the test, the existing ½-inch inner diameter (ID) straw stingers installed within wells HSVE-057, HSVE-059, HSVE-060 were replaced with 1-inch ID clear braided straw stingers to improve water and vapor recovery rates. The newly installed stingers were equipped with a cam-lock fitting to allow for the use of a portable flowmeter and water knock out tank to measure the rate of vapor and groundwater recovery. Figure 19 provides a schematic of the vapor and water measurement equipment used during the test.

The use of straw stingers allows for combined water and air extraction, referred to as TPE. Water is extracted using an airlift technique wherein air moving at high velocity entrains water droplets at the air-water interface and conveys them upward into the horizontal conveyance line. The terminal end of each stinger consists of a beveled tip, which allows for continued airflow at high velocity and reduces the likelihood of deadheading (i.e., no movement of air or water). At the start of the enhanced TPE test, the groundwater within each of the test wells was removed using the existing straw stinger. The straw stinger was slowly lowered to extract groundwater and expose a minimum of 2 feet of well screen. This process took approximately 20 minutes at each of the extraction wells. The volume of water removed prior to the start of the test was between 11.5 gallons (well HSVE-060) and 14.2 gallons (well HSVE-059), which is minimal compared to the overall volume of groundwater recovered during the enhanced TPE test (approximately 20,000 gallons). During the enhanced TPE test, the valves controlling vapor and groundwater flow were completely opened within the three extraction wells and the full system vacuum was directed through the straw stingers to maximize the rates of recovery.

Fluid levels in the three SVE wells along with select monitoring locations (HMW-004, HMW-048B, and MP-085B) were recorded periodically to evaluate drawdown within the Rand stratum during the test. It is important to note that fluid level measurements collected within the operating extraction wells are qualitative, as the vacuum must either be disrupted or shutdown prior to gauging. In the case of the three extraction wells used for the enhanced TPE test, there is a small sample port in each of the well caps that is utilized for fluid level measurements. The cap is removed from the sample port and an interface probe is quickly lowered to air-water interface; however, this process temporarily disrupts the casing vacuum, and likely results in lower measured groundwater elevations than those present under normal casing vacuum during operation of the well. It is assumed that once the system vacuum is reapplied, the groundwater elevation increases such that the air-water interface rebounds to the approximate depth of the tip of the stinger.

Air and water flowrates were recorded daily. Air flowrates recorded on March 1 through 8 were measured using a 1.5-inch diameter national pipe thread (NPT) Dwyer VFLO venturi flowmeter equipped with a 2000 Series Magnehelic® differential pressure gauge with a dual scale that provided differential pressure (0-40 inches of water) and air flowrate (0-100 standard cubic feet per minute [scfm]) measurements. Following the startup of the test, it was determined that the air flowrate range was too broad to accurately assess low air flowrates; therefore, a smaller range magnehelic gauge (0-50 scfm) was acquired and used for measurements collected on March 7 and 8. However, even with the smaller range gauge, low air flowrates observed during the test were difficult to accurately record. Therefore, an alternate venturi flowmeter (Preso® differential pressure flow meter model LPL) was used for measurements collected on March 8 through 11, as shown on Table 7. Measurements collected using the Preso® meter are considered to be more accurate than measurements taken using the Dwyer meter due to the smaller scale range on the Preso® meter. However, measurements collected using the Dwyer meter were not inconsistent with those collected using the Preso® meter, which indicated low to no air flow during the test, as discussed further in Section 4.2.

Total volatile petroleum hydrocarbon and methane concentrations were measured using a Thermoscientific™ TVA1000B® flame ionization detector (FID). During the first several days of the test, there was no observed airflow; therefore, soil vapor samples were not collected for the purpose of measuring the total volatile petroleum hydrocarbon and methane concentrations until March 7.

4.2. RESULTS

During the enhanced TPE test, approximately 20,000 gallons of perched groundwater was removed from the three test wells, with an average water removal rate from each extraction well as follows:

- HSVE-057: 0.60 gallons per minute (gpm)/863 gallons per day [gpd])
- HSVE-059: 0.50 gpm/714 gpd
- HSVE-060: 0.27 gpm/386 gpd

In addition to the water removal rates estimated for each well using the in-line knockout tank, water removal rates were also measured within the Main Header transmitting all of the recovered soil vapor and groundwater to the thermal treatment system located on the Premcor facility. Prior to the start of the test, the water removal rate for the entire SVE system was 1,000 gpd as recorded on February 29, 2016. During the enhanced TPE test the water removal rate increased to between 2,600 and 2,800 gpd. Following the enhanced TPE test, the water removal rate decreased to 1,400 gpd, as recorded on March 14, 2016. Note that towards the end of the test, the river stage increased and precipitation was recorded between March 10 and 11, 2016 (a total of 0.3 inches), which would have also resulted in increased water removal rates following completion of the test. Based on the aggregate measurements recorded within the Main Header, it is estimated that the combined water removal rate from the three wells utilized during the enhanced TPE test were between 1,200 to 1,800 gpd. The estimated average groundwater extraction rate for the enhanced TPE test using data collected from each well using the knockout tank was 1,963 gpd, only slightly higher than the maximum estimated using aggregate flowrate measurements from the Main Header.

Water generated from these three wells during the enhanced TPE test accounted for approximately 70% of the total water generated from the vapor collection system over the 11-day test. Drawdown within the test wells averaged 13.5 feet, which resulted in between 3.5 and 4.75 feet of open screen within the test wells. Perched water within the Rand stratum was depressed by an average of 1.94 feet in the adjacent groundwater monitoring wells. The greatest drawdown was observed in groundwater monitoring well HMW-004.

A summary of the airflow and groundwater recovery rates, total volatile petroleum hydrocarbon concentrations, and corresponding mass removal rates are provided on Table 7. It is important to note that during the first four days of the test (March 1 through March 4, 2016) airflow was measured using a Dwyer VFLO venturi flowmeter equipped with a magnehelic gauge that provided a broad range for measuring air flowrate (0-100 scfm) with the lowest scale reading at 20 scfm, as discussed in Section 4.1. A smaller range magnehelic gauge (0-50 scfm) was acquired and used for measurements collected on March 7 and 8. Therefore, it is possible that airflow was occurring between 0 and 20 scfm during the first four days and between 0 and 10 scfm on March 7 and 8th but could not be accurately measured with the magnehelic gauges. It is unlikely that the air flowrates recorded between March 1 and March 8, 2016 were higher than those measured during the final four days of the test (between 0.69 and 4.3 scfm) using the Preso® meter. The moisture content within the pore spaces between the silts and fine sands that makeup the Rand stratum would have been higher during the first seven days of the test and decreased over the final four days of the test as dewatering and decreasing water levels (as measured in the nearby monitoring locations) continued until March 10 and 11, 2016, when 0.3 inches of precipitation was recorded at the Hartford Site. Ideally, more accurate vapor flowrate measurements would have been recorded during the first seven days of the test; however, this would not have impacted the outcomes of the test as the mass removal rates remained very low even during the final four days of the test when flowrate measurements were more accurately recorded using the Preso® meter.

Airflow was not observed within any of the TPE test wells until March 4, 2016, four days after the start of the test. Between March 4 and 8, 2016, airflow was only measured within well HSVE-059. The observed airflow within well HSVE-059 was reportedly as high as 15 scfm; however, this measurement was recorded using the 0-100 scfm range, magnehelic gauge, where the lowest scale reading was 20 scfm and is likely inaccurate given that the readings the day before and the day after were reported at 0 scfm. Additionally, the air flowrate at HSVE-059 ranged between 1.35 and 2.69 scfm using the Preso® meter, which would further support that the actual value was lower than 15 scfm, given that the Preso® readings were taken later in the test, when the moisture content in the Rand stratum would have been lower. The following table presents airflow and corresponding mass removal rates recorded during the final four days of the enhanced TPE test, when air flowrates where measured using the Preso® meter.

Extraction Well	Date	Air Flow Rate (scfm)	Mass Removal Rate (pounds/day)
HSVE-057	3/8/2016	4.30	0.10
	3/9/2016	3.57	0.04
	3/10/2016	3.57	0.04
	3/11/2016	3.60	--
HSVE-059	3/8/2016	2.69	3.55
	3/9/2016	1.78	0.10
	3/10/2016	1.35	0.08
	3/11/2016	1.51	--
HSVE-060	3/8/2016	1.20	0.00
	3/9/2016	0.69	0.04
	3/10/2016	1.16	0.00
	3/11/2016	0.83	--

The maximum cumulative mass recovery rate from the three wells during the enhanced TPE test was 3.65 pounds/day (March 8, 2016). For comparison, the estimated mass recovery rate from the entire vapor collection system during March 2016 was 4,285 pounds/day. The mass of volatile petroleum hydrocarbons recovered from the test wells represented 0.09% of the mass recovery from the entire vapor collection system during the 11-day test.

While the enhanced TPE test showed that increasing the rate of water intake would allow for sporadic operation of the SVE wells installed within the Rand stratum within Zone 6, the rate of water recovery compared to the rate of hydrocarbon mass recovery indicates that this approach is not practicable even under seasonal low water level conditions. Significant reconfiguration of the vapor collection and thermal treatment systems, as well as water management methodology would be necessary to handle the additional volume of water if the wells installed within the Rand stratum in Zone 6 were operated in this manner in the future, which is not supported by the results of the enhanced TPE test.

SECTION 5.0
VAPOR COLLECTION SYSTEM EVALUATION

An evaluation of the existing SVE well network, construction details, operations, monitoring, and maintenance activities was performed to determine if modifications or enhancement of the vapor collection system could improve mass recovery within Zone 6.

5.1. STATIC VACUUM DISTRIBUTION

Static vacuum is measured within the nested vapor probes and multipurpose monitoring points as part of quarterly effectiveness monitoring of the vapor collection system (Table 6). Figure 20 provides a summary of the static vacuum distribution within the North Olive stratum during quarterly events conducted in May 2015, September 2015, November 2015, and February 2016. An evaluation of the vacuum distribution within the deeper stratum was not considered since these hydrostratigraphic units are typically saturated throughout the year beneath Zone 6. It should be noted that static vacuum measurements from the entire monitoring network (excluding measurements from the vapor extraction wells) were used to create the isopleths depicted on Figure 20. Therefore, influences from wells operating proximal to Zone 6 may influence the depicted vacuum distribution within the effectiveness monitoring network. There is substantial variability in the observed vacuum distribution between the quarterly events due to several factors including:

- Number and location of the SVE wells operating during the effectiveness monitoring event
- Number and location of the nested soil vapor monitoring probes and multipurpose monitoring points that are able to be screened during an event
- Elevation of groundwater within the perched, shallow stratum
- Rate of precipitation in the weeks and months leading up to the monitoring event

Operations within the SVE network in Zone 6 varied significantly during the four quarterly events. Additionally, the probes and monitoring points that were monitored also varied during each event. These variations in the operating extraction wells and locations monitored during an event are summarized on the following table.

Quarterly Event	May 2015	September 2015	November 2015	February 2015
Number of Operating SVE Wells	10	4	6	3
Locations Monitored during the Event	29	19	25	19

Most commonly, an extraction well was not operating during an event due to the well screen being occluded with perched groundwater. Similarly, field screening activities could not be conducted in those monitoring locations where the well screen was submerged beneath groundwater. Precipitation is the dominant recharge mechanism influencing groundwater elevations in the North Olive stratum. A summary of the monthly precipitation totals between April 2015 and March 2016 is summarized in the following table.

Month	Total Precipitation (inches)
April 2015	1.46
May 2015	**4.78**
June 2015	9.20
July 2015	2.90
August 2015	5.70
September 2015	**0.50**
October 2015	0.70
November 2015	**5.40**
December 2015	10.35
January 2016	0.70
February 2016	**5.00**
March 2016	1.10

Note: Quarterly effectiveness monitoring conducted during those months depicted in bold

Precipitation totals were similar in May 2015, November 2015, and February 2016 while there was significantly less rain in September 2015. However, higher precipitation rates were observed in the months leading up to the September 2015, November 2015, and February 2016 monitoring events, which would have resulted in a reduced number of operating wells and locations monitored during each event. It has been observed that perched water may take several weeks (or months) to drain from the North Olive stratum following sustained periods of heavy precipitation, such as those observed between June 2015 and February 2016. Overall, the vacuum distribution within the North Olive stratum beneath Zone 6 can be summarized as follows:

- Operation of SVE wells within adjacent Zone 1 and Zone 5 affect the vacuum distribution observed beneath Zone 6
- An episodic decrease in vacuum is observed in the central portions of Zone 6 within the North Olive stratum, particularly during periods following heavy precipitation events.

The episodic decrease in the static vacuum distribution within the central portion of Zone 6 may be caused by the reduced number of SVE wells operating during some of the effectiveness monitoring events; however, this may also be attributed to the limited spatial distribution of monitoring locations that are field screened within this portion of the Hartford Site. Recommendations regarding modifications to the SVE well and effectiveness monitoring networks in Zone 6 are summarized in Section 6.0 and discussed further within the following subsections herein.

5.2. VOLATILE HYDROCARBON DISTRIBUTION AND MASS RECOVERY RATES

As described in Section 3.5, soil vapor samples were collected and field screened for total volatile petroleum hydrocarbons during the quarterly SVE effectiveness monitoring events performed between the second quarter 2015 and first quarter 2016 (Table 6). The concentrations of total volatile petroleum hydrocarbons measured in the nested vapor monitoring probes and multipurpose monitoring points primarily screened in the North Olive stratum were compared to the mass recovery rates from the operating SVE wells during each of the quarterly events, as shown on Figure 18. The mass recovery rates for Zone 6, provided on Table 2, can be summarized as follows:

- <u>May 2015</u> – Mass removal rates were estimated at eight operating SVE wells and varied between 0 and 1000 pounds per day (lbs/day) with the highest mass recovery reported within well HSVE-099.
- <u>September 2015</u> – Mass removal rates were estimated at four operating SVE wells and varied between 3.3 and 550 lbs/day with the highest mass recovery reported within well HSVE-099
- <u>November 2015</u> – Mass removal rates were estimated at four operating SVE wells and varied between 0 and 860.2 lbs/day with the highest mass recovery reported within well HSVE-099.
- <u>February 2016</u> - Mass removal rates were estimated at five operating SVE wells and varied between 0 and 371.3 lbs/day with the highest mass recovery reported within well HSVE-077.

The highest mass recovery rates within Zone 6 are typically observed in well HSVE-099. This correlates with elevated total volatile petroleum hydrocarbons measured in soil vapor collected from the North Olive stratum within the central portion of Zone 6. Operation of additional SVE wells near well HSVE-099 would likely improve mass recovery within Zone 6. This could include resolving ongoing operational issues within nearby SVE wells HSVE-001S/D and HSVE-030S/D (further described in Section 5.4) and installation of an additional extraction well to the north of well HSVE-099.

5.3. VAPOR RECOVERY USING TEMPORARY TUBING

Mass recovery was observed to be greatest during 2012, primarily due to historical low groundwater elevations within the hydrostratigraphic units across the Hartford Site. However, during this time, there was also a focused effort to improve mass recovery by connecting multipurpose monitoring points, groundwater monitoring wells, and large diameter recovery wells to the SVE system using aboveground, temporary tubing. While it is not recommended that this process be reintroduced, mass recovery during 2012 was evaluated to determine if the locations used for vapor recovery using temporary tubing in Zone 6 would be ideal for an additional SVE well.

Temporary vapor removal was primarily performed in this fashion in Zone 6 by connecting groundwater monitoring well HMW-009, monitoring point MP-106B, and recovery well RW-002 to extraction well HSVE-075. As shown on Figure 21, these three wells and monitoring points are located in the south central portion of Zone 6, west of North Olive Avenue between East Cherry and East Date Streets. Currently, there are no SVE wells installed within this portion of Zone 6. Well completion details for the three wells and monitoring points used for temporary vapor removal in Zone 6 are provided in the following table.

Location	Casing Diameter	Top of Screen	Bottom of Screen	Total Depth	Stratum
	(inches)	(ft-bgs)	(ft-bgs)	(ft-bgs)	
HMW-009	2	12.71	22.91	22.91	--
MP-106B	1	9.99	14.00	14.10	North Olive
RW-002	30	--	--	51.02	--

Mass removal rates during these temporary events averaged 800 pounds/hour and were as high as 1,600 pounds/hour, with the highest rates observed when recovery well RW-002 was connected to the vapor collection system. For comparison the monthly mass recovery rate from all of the operating SVE wells in Zone 6 ranged between 0.5 and 1,771 pounds/hour between April 2015 and March 2016 (Table 2).

It is important to note that recovery well RW-002 has a large diameter (30-inch) and extends into the Main Sand stratum, with a total depth of 50-feet. There is often measurable LNAPL within the recovery well (Table 4), which would result in higher mass recovery due to partitioning of vapor from the large LNAPL-air interface within the recovery well, which may not necessarily reflect removal of mass from the surrounding formation. As previously discussed, wells installed in the deeper hydrostratigraphic units in Zone 6 have largely been inoperable due to occlusion of the well screen with groundwater, even when recovering groundwater at higher rates via enhanced TPE (Section 4.2). Installation of an additional vapor extraction well, screened within the North Olive stratum, in the south central portion of Zone 6 (between East Cherry and East Date Streets) may improve mass recovery.

5.4. WELLS HSVE-001S/D AND HSVE-030S/D

SVE wells HSVE-001S/D and HSVE-030S/D have been largely inoperable since installation because the horizontal transmission line (installed as part of the Phase I and II expansion) connecting these wells to the vapor collection system is routinely blocked with water and silt. Routine maintenance has been performed in the past to remove accumulated water and silt from the transmission line extending to these wells. However, due to low points and bends within the Phase I and II transmission line, water and silt quickly re-accumulate limiting operations within these wells.

Based on the design and as-built drawings provided by the Harford Working Group, it appears that these four extraction wells were slated to be connected to the new transmission lines installed during the Phase III expansion of the vapor collection system. Despite these plans, the wells were never connected to the Phase III transmission system by the Hartford Working Group. As shown on Figure 3, SVE wells HSVE-001S/D and HSVE-30S/D are located approximately 165 feet and 50 feet south of HSVE-099, respectively. Extraction well HSVE-099 has been largely operable (89%) and recovered the majority of the total mass (60%) from Zone 6 over the past year. A cross section of the SVE wells installed in Zone 6 is provided on Figure 5 and a summary of the well construction details for extraction wells, HSVE-001S/D, HSVE-030S/D, and HSVE-099 is provided in the following table.

Extraction Well	Top of Screen	Bottom of Screen	Stratum
	(ft-bgs)	(ft-bgs)	
HSVE-001S	6.7	11	North Olive and overlying A clay
HSVE-001D	5.8	16	North Olive, overlying A clay and underlying B clay
HSVE-030S	7.4	13	North Olive and underlying B clay
HSVE-030D	11.7	24	Rand
HSVE-099	9.1	15.4	North Olive and underlying B clay

In an effort to improve mass recovery within the central portion of Zone 6, the following activities are recommended:

- **Connect SVE Wells HSVE-001D and HSVE-030S to the Phase III Transmission Lines**: Extraction wells HSVE-001D and HSVE-030S were constructed with screen intervals that are similar to well HSVE-099, within and extending through the North Olive stratum. Connection of wells HSVE-001D and HSVE-030S to the Phase III transmission lines will require reconfiguration of the existing well vaults, as well as limited trenching and pipe connections.
- **Plug and Abandon SVE Well HSVE-001S**: Extraction well HSVE-001S is screened across the upper portion of the North Olive stratum and into the overlying A-Clay. The screen interval within this shallow extraction well overlaps with the screen interval installed in the paired SVE well HSVE-001D. In many cases, when paired extraction wells have been constructed in this manner at the Hartford Site there has been breakthrough of atmospheric oxygen into both extraction wells during operations. This has typically been referred to as short circuiting (e.g., wells HSVE-025S/D on West Birch Street in SVE Effectiveness Zone 1).

Any future work performed to connect wells HSVE-001D and HSVE-030S to the Phase III transmission lines or to plug and abandon well HSVE-001S will be coordinated with the Village of Hartford to minimize damage to current infrastructure including roadways and subgrade utilities.

SECTION 6.0
RECOMMENDATIONS

Since submittal of the *90% Design Report* (Clayton, et al. 2006), 24 additional extraction wells have been installed in Zone 6 of the Hartford Site. The *90% Design Report* (Clayton, et al. 2006) envisioned installation of 25 extraction wells within the Rand strata and 10 additional vapor extraction wells within the deeper, more permeable strata (referred to as the EPA and Main Sand Strata) in Zone 6. As detailed herein, many of these additional extraction wells installed in Zone 6 (particularly those wells installed in the Rand stratum along North Olive Avenue) have not been operable and have contributed negligibly to mass recovery due to occlusion of the well screen with groundwater since installation. This occurs despite extensive efforts to install stingers within the extraction wells and recover groundwater via TPE instead of operating the wells to solely recover vapors, as originally designed.

In an effort to continue to optimize and implement the vapor extraction components of the *90% Design Report* (Clayton, et al. 2006), Apex has conducted additional testing and evaluation of the infrastructure and operations within Zone 6. These activities, described herein, have focused on defining the geologic, hydrologic, construction, and operational criteria that have contributed to elevated volatile hydrocarbon recovery in specific locations during specific timeframes within Zone 6. The following recommendations are being proposed following completion of these activities.

1. As described in Section 3.0, a more detailed 3D visualization analysis of the lithology described during installation of soil borings was prepared and subsequently compared to the generalized 3D stratigraphic interpretation of the geologic setting. The detailed lithologic interpretation is useful in illustrating the highly heterogeneous and interbedded nature of the reworked alluvial and glacial sediments in the upper 40 feet of the subsurface beneath Zone 6. In particular, this interpretation illustrates the discontinuous nature of clay lenses deeper than 10 feet below ground surface (ft-bgs). These clays are shown as continuous units within the generalized stratigraphic interpretation but are more definitively represented as isolated lenses within the detailed lithologic interpretation. However, while the detailed lithologic interpretation depicts a more nuanced and discontinuous setting within the upper 40 feet of the subsurface compared to the generalized stratigraphic interpretation, it is not any more accurate in showing the actual geology measured via Cone Penetration Testing. Although the model provides a better sense of the distribution of glaciofluvial deposits in the shallower portions of the subsurface, detailed analyses using existing lithologic logs and additional soil borings will be necessary when

designing new recovery wells at the Hartford Site, including proposed wells in Zone 6. If specific data gaps are identified in the conceptual site model that may be resolved through further evaluation of the detailed 3D visualization analysis of the lithology, then additional modelling could be performed in focused portions of the Hartford Site, similar to the analysis completed for Zone 6.

2. As discussed in Section 4.0, field testing of increased water recovery rates (using the existing vapor collection system infrastructure) was performed within selected extraction wells screened in the Rand stratum along North Olive Avenue (referred to as an enhanced TPE test) in an effort to improve the operability of these wells. This test was performed in a portion of the Rand stratum in Zone 6 known to be underlain with residual LNAPL that has not been targeted for recovery via SVE due to occlusion of the well screens since installation. The enhanced TPE test was performed to determine if increasing water recovery using existing SVE wells and infrastructure would result in (1) exposure of the screen in the operating wells (2) sustained unsaturated conditions within the extraction wells and nearby monitoring locations, and (3) increased mass removal rates for petroleum hydrocarbons. The enhanced TPE test showed that increasing the rate of water intake would allow for sporadic operation of the deeper SVE wells installed within Zone 6, under seasonal low water level conditions. However, the rate of water recovery compared to the rate of hydrocarbon mass recovery indicates that this approach is not practicable. Significant reconfiguration of the vapor collection and thermal treatment systems, as well as water management methodology would be necessary for incremental increases in mass recovery rates. Therefore, Apex is recommending to continue to operate the extraction wells in Zone 6 as described within the *Final Vapor Collection System OMM Plan* (Trihydro 2015).

3. As provided in Section 5.0, an evaluation of the existing SVE well network, construction details, operations, monitoring, and maintenance activities was performed to determine if modification or enhancement of the vapor collection system could improve mass recovery within Zone 6. Figure 21 provides a summary of the recommendations for modifying the extraction well and effectiveness monitoring networks within Zone 6 based on these analyses.

    - Connect existing SVE wells HSVE-001D and HSVE-030S to the Phase III transmission lines; while concurrently abandoning extraction well HSVE-001S.

    - Install two additional extraction wells, one located to the north of well HSVE-099 and the second located to the west of SVE wells HSVE-075 and HSVE-076. Potential locations for these two additional vapor extraction wells (with proposed designations HSVE-108 and HSVE-109) are depicted on Figure 21.

- Perform effectiveness monitoring within multipurpose monitoring points MP-106A and MP-109B screened in the North Olive stratum on a quarterly basis in accordance with the *Effectiveness Monitoring Plan* (URS 2014).
- Install seven additional vapor monitoring probes (with proposed designations VMP-106S through VMP-112S, as shown on Figure 21) within the North Olive stratum and perform effectiveness monitoring on a quarterly basis in accordance with the *Effectiveness Monitoring Plan* (URS 2014) to better assess vacuum distribution and total volatile petroleum hydrocarbon concentrations within the central portions of Zone 6.

In addition to the recommendations outlined above, the USEPA requested installation of up to four additional SVE wells within North Olive Avenue in Zone 6 via correspondence dated October 4, 2016, titled *Secondary Review Comments on Apex Oil Company, Inc. Response to USEPA Comments, Draft Soil Vapor Extraction System Effectiveness Zone 6 Optimization Report* (*Secondary Review Comments*). Apex agreed to the installation of the two northernmost SVE wells proposed by the USEPA in their response to the *Secondary Review Comments* on October 13, 2016. However, installation of these two additional SVE wells within North Olive Avenue would be difficult as the roadway was recently repaved by the Village of Hartford. Therefore, Apex will evaluate installation of the two additional SVE wells on private property at locations proximal to North Olive Avenue. The two proposed extraction wells (designated as HSVE-110 and HSVE-111) are depicted on Figure 21 to be in close proximity to North Olive Avenue, but the actual location may be modified during design and/or installation. Apex and USEPA agreed that additional data will be collected as part of routine effectiveness monitoring within Zone 6 to determine if any additional extraction wells may be needed to further optimize recovery of petroleum hydrocarbons in the North Olive stratum following installation of the four additional extraction wells and connection of SVE wells HSVE-001D and HSVE-030S to the Phase III transmission lines.

6.1. STAKEHOLDER COORDINATION

In order to complete the recommended activities and begin optimization of vapor recovery within Zone 6, coordination with multiple stakeholders is required. The following coordination activities will be necessary:

- **Village of Hartford**: A meeting with the Village of Hartford will be necessary to coordinate access to the Village right-of-way along portions of East Birch Street and the connecting alleys to the east and south of East Birch Street where wells HSVE-001S/D and HSVE-030S/D are located.

Plans (including notices) will need to be developed to minimize the impact on residents and businesses during the modification of the extraction wells and transmission lines.

- **USEPA and Illinois EPA**: Additional discussions with USEPA and Illinois EPA will be performed as needed to gain concurrence with the approach for optimizing the vapor collection system in Zone 6. Apex will provide notification to the USEPA and Illinois EPA regarding progress towards: (1) finalizing access to the Village of Hartford right-of-ways, and (2) finalizing subcontract agreements and specifications for installation, abandonment, and other related construction activities. A schedule for installation of the proposed vapor monitoring probes, abandonment of the two extraction wells, connection of the two existing SVE wells to the Phase III transmission system, initiation of vapor recovery using SVE wells HSVE-001D and HSVE-030S, quarterly monitoring within the expanded SVE effectiveness monitoring network, and evaluation of the routine data collected during the quarterly monitoring events will be prepared in collaboration with the USEPA and Illinois EPA. Following analysis of the additional quarterly monitoring events, Apex will develop detailed engineering plans, specifications, and bid documents for installation of additional vapor extraction wells in the central portions of Zone 6, if warranted.

SECTION 7.0
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TABLES

TABLE 1. SOIL VAPOR EXTRACTION WELL DETAIL SUMMARY

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Well ID	Shallow/ Deep	Screen Location	Considered Part of System[1]	Top of Screen	Bottom of Screen	Screen Length	Online[1]	Stinger Type	Stinger Diameter	Flow Meter Type
			(Y/N)	(ft-btoc)	(ft-btoc)	(feet)	(%)		(inches)	
HSVE-001D	Deep	N. Olive	Y	5.76	15.76	10.00	0.00	Flow Tube	2.0	Pitot Tube
HSVE-001S	Shallow	N. Olive	Y	6.69	11.09	4.40	0.00	Flow Tube	2.0	Pitot Tube
HSVE-030D	Deep	Rand	Y	18.72	24.22	5.50	0.00	Viton Stinger	1.0	Pitot Tube
HSVE-030S	Shallow	N. Olive	Y	7.38	12.88	5.50	0.00	Viton Stinger	1.5	Pitot Tube
HSVE-031S	Shallow	A Clay	N	6.09	8.09	2.00	0.00	None	--	Venturi
HSVE-055	Deep	Rand	Y	17.41	23.96	6.55	0.00	None	--	Venturi
HSVE-056	Deep	Rand	Y	16.57	23.12	6.55	0.00	Straw Stinger	0.5	Venturi
HSVE-057	Deep	Rand	Y	20.46	27.07	6.61	0.00	Straw Stinger	0.5	Venturi
HSVE-058	Shallow	N. Olive	Y	9.59	15.12	5.53	0.79	Viton Stinger	1.0	Venturi
HSVE-059	Deep	Rand	Y	17.54	25.11	7.57	0.00	Straw Stinger	0.5	Venturi
HSVE-060	Deep	Rand	Y	17.83	24.31	6.48	0.00	Straw Stinger	0.5	Venturi
HSVE-061	Shallow	N. Olive	Y	11.75	16.24	4.49	0.12	Straw Stinger	0.5	Venturi
HSVE-062	Shallow	N. Olive	Y	6.12	9.65	3.53	0.74	Viton Stinger	1.0	Venturi
HSVE-063	Deep	Rand	Y	14.55	21.07	6.52	0.00	Straw Stinger	0.5	Venturi
HSVE-064	Shallow	N. Olive	Y	8.41	10.91	2.50	0.33	None	--	Venturi
HSVE-065	Deep	Rand	Y	14.48	21.02	6.54	0.00	Straw Stinger	0.5	Venturi
HSVE-066	Deep	Rand	Y	17.54	21.06	3.52	0.00	Straw Stinger	0.5	Venturi
HSVE-067	Shallow	N. Olive	Y	8.48	12.00	3.52	0.34	Straw Stinger	0.5	Venturi
HSVE-068	Deep	Rand	Y	17.47	20.98	3.51	0.00	Straw Stinger	0.5	Venturi
HSVE-069	Deep	Rand	Y	18.59	22.10	3.51	0.00	Straw Stinger	0.5	Venturi
HSVE-070	Shallow	N. Olive	Y	8.60	13.08	4.48	0.70	Viton Stinger	1.0	Venturi
HSVE-071	Deep	Rand	Y	17.58	25.13	7.55	0.38	Viton Stinger	1.0	Venturi
HSVE-072	Deep	Rand	Y	17.70	22.19	4.49	0.23	Viton Stinger	1.0	Venturi
HSVE-073	Deep	Rand	Y	17.55	21.07	3.52	0.00	Straw Stinger	0.5	Venturi
HSVE-074	Shallow	N. Olive	Y	9.49	13.00	3.51	0.37	Viton Stinger	1.0	Venturi
HSVE-075	Deep	Rand	Y	19.54	23.06	3.52	0.00	None	--	Venturi

TABLE 1. SOIL VAPOR EXTRACTION WELL DETAIL SUMMARY
HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Well ID	Shallow/ Deep	Screen Location	Considered Part of System[1]	Top of Screen	Bottom of Screen	Screen Length	Online[1]	Stinger Type	Stinger Diameter	Flow Meter Type
			(Y/N)	(ft-btoc)	(ft-btoc)	(feet)	(%)		(inches)	
HSVE-076	Deep	Rand	Y	18.66	22.17	3.51	0.12	Viton Stinger	1.0	Venturi
HSVE-077	Shallow	N. Olive	Y	8.65	13.13	4.48	1.00	Viton Stinger	1.0	Venturi
HSVE-099	Shallow	Multiple Strata	Y	9.08	15.37	6.29	0.89	Viton Stinger	1.0	Venturi

Notes:
[1] - measurements recorded since April 2015, does not include the enhanced TPE test at HSVE-057, HSVE-059, and HSVE-060
ft-btoc - feet below top of casing
NA - not available
-- - not applicable
scfm - standard cubic feet per minute
TVPH - total volatile organic compounds
ppmv - parts per million by volume

TABLE 2. VAPOR EXTRACTION FLOW RATE AND MASS REMOVAL ESTIMATES

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Zone	Stratum	April 2015			May 2015			June 2015			July 2015			August 2015			September 2015		
			Flow Rate (scfm)	TVPH (ppmv)	Mass Removal Rate (lbs/day)	Flow Rate (scfm)	TVPH (ppmv)	Mass Removal Rate (lbs/day)	Flow Rate (scfm)	TVPH (ppmv)	Mass Removal Rate (lbs/day)	Flow Rate (scfm)	TVPH (ppmv)	Mass Removal Rate (lbs/day)	Flow Rate (scfm)	TVPH (ppmv)	Mass Removal Rate (lbs/day)	Flow Rate (scfm)	TVPH (ppmv)	Mass Removal Rate (lbs/day)
HSVE-058	Zone 6	North Olive	10	6,200	21	13	3,800	16	15	8,700	43	16	3,400	18	--	--	--	--	--	--
HSVE-061	Zone 6	North Olive	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HSVE-062	Zone 6	North Olive	8.9	730	2.1	11	3,500	12	15	6,100	29	--	--	--	--	--	--	7.8	1,300	3.3
HSVE-064	Zone 6	North Olive	20	NM*	NM*	19	15	0.091	--	--	--	--	--	--	--	--	--	--	--	--
HSVE-067	Zone 6	North Olive	8.8	NM*	NM*	NM**	11	--	NM**	23	NM**	--	--	--	--	--	--	--	--	--
HSVE-070	Zone 6	North Olive	2.5	29	0.023	5.5	11	0.020	11	18	0.068	0.0	280	0.0	--	--	--	6.8	1,800	4.0
HSVE-071	Zone 6	Rand	0.0	0.0	0.0	2.7	NM*	NM*	--	--	--	--	--	--	--	--	--	--	--	--
HSVE-072	Zone 6	Rand	0.0	5,100	0.0	0.0	76	0.0	--	--	--	--	--	--	--	--	--	--	--	--
HSVE-074	Zone 6	North Olive	14	NM*	NM*	12	5.0	0.020	12	5.0	0.019	--	--	--	--	--	--	--	--	--
HSVE-076	Zone 6	Rand	0.0	0.0	0.0	0.0	NM*	NM*	--	--	--	--	--	--	--	--	--	--	--	--
HSVE-077	Zone 6	North Olive	3.8	260,000	330	13	990	4.1	7.2	NM*	NM*	7.9	2,600	6.6	6.1	260	0.5	16	79,000	410
HSVE-099	Zone 6	Multiple Strata	15	420	2.0	38	83,000	1000	30	24,000	240	54	1,700	30	--	--	--	34	50,000	550
TOTAL MASS REMOVAL					**355**			**1,032**			**312**			**55**			**0.5**			**967**

Location	Zone	Stratum	October 2015			November 2015			December 2015			January 2016			February 2016			March 2016		
			Flow Rate (scfm)	TVPH (ppmv)	Mass Removal Rate (lbs/day)	Flow Rate (scfm)	TVPH (ppmv)	Mass Removal Rate (lbs/day)	Flow Rate (scfm)	TVPH (ppmv)	Mass Removal Rate (lbs/day)	Flow Rate (scfm)	TVPH (ppmv)	Mass Removal Rate (lbs/day)	Flow Rate (scfm)	TVPH (ppmv)	Mass Removal Rate (lbs/day)	Flow Rate (scfm)	TVPH (ppmv)	Mass Removal Rate (lbs/day)
HSVE-058	Zone 6	North Olive	--	24300	--	12.0	56200	220.4	--	--	--	16.9	3	0.02	9.1	670	2.0	5.8	370	0.7
HSVE-061	Zone 6	North Olive	--	65000	--	NM**	1120	NM**	NM**	35	NM**	--	--	--	--	--	--	--	--	--
HSVE-062	Zone 6	North Olive	94.8	23800	737.7	8.7	NM*	NM*	5.7	65	0.1	--	--	--	0.0	200	0.0	0.0	2087	0.0
HSVE-064	Zone 6	North Olive	7.8	25	0.1	--	35	--	32.5	20	0.2	--	--	--	--	9	--	--	47	--
HSVE-067	Zone 6	North Olive	NM**	7	NM**	--	30	--	--	29	--	--	--	--	--	5	--	--	30	--
HSVE-070	Zone 6	North Olive	0.0	2600	0.0	--	4060	--	8.9	315	0.9	--	12400	--	5.6	3925	7.2	0.0	25200	0.0
HSVE-071	Zone 6	Rand	0.0	6720	0.0	0.0	19800	0.0	7.4	12300	29.9	--	--	--	--	35	--	--	820	--
HSVE-072	Zone 6	Rand	--	21	--	--	143	--	--	105	--	--	--	--	--	11	--	--	18	--
HSVE-074	Zone 6	North Olive	--	8	--	--	530	--	23.8	37	0.3	--	--	--	--	3	--	--	9	--
HSVE-076	Zone 6	Rand	--	NM*	--	--	NM*	--	--	--	--	--	--	--	--	--	--	16.9	38300	212.2
HSVE-077	Zone 6	North Olive	8.1	86000	229.0	*	*	224.22*	*	*	224.22*	6.9	97800	219.44	10.3	110000	371.3	10.3	114000	383.3
HSVE-099	Zone 6	Multiple Strata	34.7	70800	804.5	45.8	57400	860.2	32.3	29000	306.7	46.7	95	1.45	48.1	13200	207.5	29.8	111200	1085.3
TOTAL MASS REMOVAL					**1,771**			**1,305**			**562**			**221**			**588**			**1,682**

Notes:
-- - well was not operating during this time period
* - HSVE-077 was parked over during November and December 2015 and could not be accessed. The average mass removal rate from November 2015 and January 2016 was used as a surrogate.
lbs/day - pounds per day
NM* - not measured due to occluded well screen
NM** - not measured, well has a straw stinger and flow rate cannot be measured
NM*** - not measured, water in pitot tube
scfm - standard cubic feet per minute
TVPH - total volatile petroleum hydrocarbons
ppmv - parts per million by volume

TABLE 3. FLUID LEVELS FOR SELECTED WELLS, NORTH OLIVE AND RAND STRATA

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Hydro-stratigraphic Unit	Confining Unit	Depth to Bottom of Confining Unit	Measuring Point Elevation	Date	Depth to LNAPL	Depth to Water	LNAPL Thickness	Groundwater Elevation	LNAPL Depth Below Confining Contact	LNAPL Condition
			(ft-bgs)	(ft-amsl)		(ft-bmp)	(ft-bmp)	(feet)	(ft-amsl)	(feet)	
MP-108B	N. Olive	A Clay	8.0	429.62	5/19/14	13.14	13.45	0.31	416.17	5.45	Highly Unconfined
					8/4/14	--	Dry	--	--	--	--
					10/27/14	13.04	13.30	0.26	416.32	5.30	Highly Unconfined
					3/9/15	--	Dry	--	--	--	--
					4/6/15	13.40	13.54	0.14	416.08	5.54	Highly Unconfined
					7/20/15	12.76	12.85	0.09	416.77	4.85	Highly Unconfined
HMW-048B	Rand	B Clay	24.4	429.18	10/1/13	--	18.30	--	410.88	-6.10	--
					11/14/13	--	18.80	--	410.38	-5.60	--
					1/14/14	--	14.97	--	414.21	-9.43	--
					2/17/14	--	18.11	--	411.07	-6.29	--
					3/20/14	--	16.42	--	412.76	-7.98	--
					4/25/14	--	12.08	--	417.10	-12.32	--
					5/12/14	--	11.06	--	418.12	-13.34	--
					6/3/14	--	10.63	--	418.55	-13.77	--
					7/24/14	--	11.41	--	417.77	-12.99	--
					8/4/14	--	12.35	--	416.83	-12.05	--
					9/8/14	--	9.98	--	419.20	-14.42	--
					10/27/14	--	9.65	--	419.53	-14.75	--
					11/20/14	--	12.18	--	417.00	-12.22	--
					12/23/14	--	12.76	--	416.42	-11.64	--
					1/23/15	--	12.61	--	416.57	-11.79	--
					2/27/15	--	15.73	--	413.45	-8.67	--
					3/9/15	--	15.73	--	413.45	-8.67	--
					4/6/15	--	11.20	--	417.98	-13.20	--
					5/12/15	--	10.60	--	418.58	-13.80	--

TABLE 3. FLUID LEVELS FOR SELECTED WELLS, NORTH OLIVE AND RAND STRATA

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Hydro-stratigraphic Unit	Confining Unit	Depth to Bottom of Confining Unit	Measuring Point Elevation	Date	Depth to LNAPL	Depth to Water	LNAPL Thickness	Groundwater Elevation	LNAPL Depth Below Confining Contact	LNAPL Condition
			(ft-bgs)	(ft-amsl)		(ft-bmp)	(ft-bmp)	(feet)	(ft-amsl)	(feet)	
HMW-048B	Rand	B Clay	24.4	429.18	6/23/15	--	8.50	--	420.68	-15.90	--
					7/20/15	6.34	6.35	0.01	422.83	-18.05	Highly Confined
					8/24/15	--	8.70	--	420.48	-15.70	--
					9/21/15	--	12.49	--	416.69	-11.91	--
MP-009D	Rand	B Clay	18.1	430.00	10/1/13	21.24	22.32	1.08	407.68	4.22	Highly Unconfined
					1/13/14	22.46	23.35	0.89	406.65	5.25	Highly Unconfined
					5/13/14	19.82	20.30	0.48	409.70	2.20	Unconfined
					8/4/14	19.41	19.71	0.30	410.29	1.61	Unconfined
					10/27/14	--	17.60	--	412.40	-0.50	Confined
					3/9/15	20.78	20.90	0.12	409.10	2.80	Unconfined
					4/7/15	9.10	9.15	0.05	420.85	-8.95	Highly Confined
					7/20/15	--	12.64	--	417.36	-5.46	Highly Confined
MP-029B	Rand	B Clay	15.5	429.43	5/12/14	--	Dry	--	--	--	--
					8/4/14	--	19.43	--	410.00	3.93	Unconfined
					10/27/14	17.11	17.13	0.02	412.30	1.63	Unconfined
					3/5/15	--	Dry	--	--	--	--
					4/6/15	--	Dry	--	--	--	--
					7/20/15	--	12.86	--	416.57	-2.64	Confined
MP-041B	Rand	B Clay	24.0	431.23	10/1/13	--	25.72	--	405.51	1.72	Unconfined
					1/14/14	25.67	25.74	0.07	405.49	1.74	Unconfined
					5/13/14	25.35	25.48	0.13	405.75	1.48	Unconfined
					8/4/14	24.68	24.93	0.25	406.30	0.93	Unconfined

TABLE 3. FLUID LEVELS FOR SELECTED WELLS, NORTH OLIVE AND RAND STRATA

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Hydro-stratigraphic Unit	Confining Unit	Depth to Bottom of Confining Unit	Measuring Point Elevation	Date	Depth to LNAPL	Depth to Water	LNAPL Thickness	Groundwater Elevation	LNAPL Depth Below Confining Contact	LNAPL Condition
			(ft-bgs)	(ft-amsl)		(ft-bmp)	(ft-bmp)	(feet)	(ft-amsl)	(feet)	
MP-041B	Rand	B Clay	24.0	431.23	10/28/14	24.63	24.75	0.12	406.48	0.75	Unconfined
					3/9/15	--	Dry	--	--	--	--
					4/7/15	--	Dry	--	--	--	--
					7/20/15	20.94	20.95	0.01	410.28	-3.05	Confined

Notes:

ft-bgs - feet below ground surface
ft-amsl - feet above mean sea level
ft-bmp - feet below measuring point

TABLE 4. FLUID LEVELS FOR SELECTED WELLS, MAIN SAND AND EPA STRATA

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Hydro-stratigraphic Unit	Confining Unit	Depth to Bottom of Confining Unit	Measuring Point Elevation	Date	Depth to LNAPL	Depth to Water	LNAPL Thickness	Groundwater Elevation	LNAPL Depth Below Confining Contact	LNAPL Condition
			(ft-bgs)	(ft-amsl)		(ft-bmp)	(ft-bmp)	(feet)	(ft-amsl)	(feet)	
HMW-008	Main Sand	C Clay	31.50	429.74	9/9/13	30.00	31.10	1.10	398.64	-1.50	Confined
					9/13/13	30.41	31.06	0.65	398.68	-1.09	Confined
					9/17/13	30.40	31.00	0.60	398.74	-1.10	Confined
					9/24/13	30.90	30.94	0.04	398.80	-0.60	Confined
					5/12/14	31.09	31.12	0.03	398.62	-0.41	Confined
					8/4/14	26.80	32.60	5.80	397.14	-4.70	Highly Confined
					10/31/14	27.40	31.41	4.01	398.33	-4.10	Highly Confined
					4/6/15	33.35	34.05	0.70	395.69	1.85	Unconfined
					10/13/15	29.78	32.78	3.00	396.96	-1.72	Confined
HMW-010	Main Sand	C Clay	31.00	430.20	9/3/13	29.70	30.60	0.90	399.60	-1.30	Confined
					9/6/13	30.00	30.60	0.60	399.60	-1.00	Confined
					9/9/13	30.25	30.60	0.35	399.60	-0.75	Confined
					9/13/13	30.70	30.80	0.10	399.40	-0.30	Confined
					9/23/13	31.08	31.14	0.06	399.06	0.08	Unconfined
					9/27/13	31.20	31.30	0.10	398.90	0.20	Unconfined
					10/1/13	31.40	31.42	0.02	398.78	0.40	Unconfined
					5/19/14	--	30.65	--	399.55	--	--
					8/4/14	27.01	30.45	3.44	399.75	-3.99	Confined
					10/27/14	26.23	30.48	4.25	399.72	-4.77	Highly Confined
					7/20/15	18.87	28.38	9.51	401.82	-12.13	Highly Confined
					10/13/15	29.84	30.64	0.80	399.56	-1.16	Confined
					1/6/16	18.69	30.80	12.11	399.40	-12.31	Highly Confined
HMW-014	Multiple Strata	C Clay	32.00	430.86	9/6/13	31.00	31.70	0.70	399.16	-1.00	Confined
					9/13/13	31.70	32.00	0.30	398.86	-0.30	Confined
					9/23/13	32.10	32.50	0.40	398.36	0.10	Unconfined

TABLE 4. FLUID LEVELS FOR SELECTED WELLS, MAIN SAND AND EPA STRATA

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Hydro-stratigraphic Unit	Confining Unit	Depth to Bottom of Confining Unit	Measuring Point Elevation	Date	Depth to LNAPL	Depth to Water	LNAPL Thickness	Groundwater Elevation	LNAPL Depth Below Confining Contact	LNAPL Condition
			(ft-bgs)	(ft-amsl)		(ft-bmp)	(ft-bmp)	(feet)	(ft-amsl)	(feet)	
HMW-014	Multiple Strata	C Clay	32.00	430.86	9/27/13	32.10	32.60	0.50	398.26	0.10	Unconfined
					10/1/13	32.39	32.96	0.57	397.90	0.39	Unconfined
					1/14/14	34.30	35.86	1.56	395.00	2.30	Unconfined
					5/13/14	31.75	32.02	0.27	398.84	-0.25	Confined
					8/4/14	--	28.67	--	402.19	--	--
					10/28/14	27.95	29.30	1.35	401.56	-4.05	Highly Confined
					4/7/15	34.10	34.50	0.40	396.36	2.10	Unconfined
					7/20/15	21.88	22.67	0.79	408.19	-10.12	Highly Confined
					10/13/15	30.78	31.72	0.94	399.14	-1.22	Confined
					1/7/16	21.07	26.62	5.55	404.24	-10.93	Highly Confined
HMW-021	Multiple Strata	C Clay	31.50	430.05	10/1/13	--	21.02	--	409.03	--	--
					1/13/14	--	22.72	--	407.33	--	--
					5/13/14	--	20.95	--	409.10	--	--
					8/4/14	--	19.87	--	410.18	--	--
					10/27/14	--	17.85	--	412.20	--	--
					3/9/15	--	21.10	--	408.95	--	--
					7/20/15	--	13.30	--	416.75	--	--
					10/13/15	--	20.50	--	409.55	--	--
					1/6/16	20.70	25.68	4.98	404.37	-10.80	Highly Confined
HMW-022	Main Sand	C Clay	31.50	430.14	9/4/13	30.10	32.70	2.60	397.44	-1.40	Confined
					9/11/13	30.75	32.90	2.15	397.24	-0.75	Confined
					9/24/13	31.40	33.20	1.80	396.94	-0.10	Confined
					9/30/13	31.70	33.40	1.70	396.74	0.20	Unconfined
					10/1/13	31.81	33.40	1.59	396.74	0.31	Unconfined
					1/13/14	33.76	36.19	2.43	393.95	2.26	Unconfined

TABLE 4. FLUID LEVELS FOR SELECTED WELLS, MAIN SAND AND EPA STRATA

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Hydro-stratigraphic Unit	Confining Unit	Depth to Bottom of Confining Unit (ft-bgs)	Measuring Point Elevation (ft-amsl)	Date	Depth to LNAPL (ft-bmp)	Depth to Water (ft-bmp)	LNAPL Thickness (feet)	Groundwater Elevation (ft-amsl)	LNAPL Depth Below Confining Contact (feet)	LNAPL Condition
HMW-022	Main Sand	C Clay	31.50	430.14	5/13/14	31.32	32.37	1.05	397.77	-0.18	Confined
					8/4/14	27.23	32.51	5.28	397.63	-4.27	Highly Confined
					10/27/14	26.44	31.85	5.41	398.29	-5.06	Highly Confined
					3/9/15	34.70	37.70	3.00	392.44	3.20	Unconfined
					4/7/15	33.75	34.34	0.59	395.80	2.25	Unconfined
					7/20/15	19.00	31.85	12.85	398.29	-12.50	Highly Confined
					10/13/15	30.28	32.04	1.76	398.10	-1.22	Confined
HMW-034	Multiple Strata	C Clay	30.00	429.83	9/5/13	29.49	30.35	0.86	399.48	-0.51	Confined
					9/9/13	29.80	30.40	0.60	399.43	-0.20	Confined
					9/10/13	30.06	30.16	0.10	399.67	0.06	Unconfined
					9/12/13	30.20	30.30	0.10	399.53	0.20	Unconfined
					9/26/13	30.77	31.00	0.23	398.83	0.77	Unconfined
					10/1/13	31.00	31.35	0.35	398.48	1.00	Unconfined
					1/14/14	33.19	33.68	0.49	396.15	3.19	Unconfined
					5/19/14	--	30.23	--	399.60	--	--
					8/4/14	26.71	29.77	3.06	400.06	-3.29	Confined
					10/27/14	25.93	29.80	3.87	400.03	-4.07	Highly Confined
					3/9/15	34.32	34.90	0.58	394.93	4.32	Highly Unconfined
					4/6/15	32.85	32.96	0.11	396.87	2.85	Unconfined
					7/20/15	19.22	28.23	9.01	401.60	-10.78	Highly Confined
					10/13/15	29.50	30.25	0.75	399.58	-0.50	Confined
					1/6/16	19.82	25.88	6.06	403.95	-10.18	Highly Confined
IEPA-004	Main Sand	C Clay	26.00	430.35	9/5/13	29.00	30.80	1.80	399.55	3.00	Unconfined
					9/12/13	29.90	29.95	0.05	400.40	3.90	Unconfined
					9/26/13	30.54	30.57	0.03	399.78	4.54	Highly Unconfined

TABLE 4. FLUID LEVELS FOR SELECTED WELLS, MAIN SAND AND EPA STRATA

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Hydro-stratigraphic Unit	Confining Unit	Depth to Bottom of Confining Unit (ft-bgs)	Measuring Point Elevation (ft-amsl)	Date	Depth to LNAPL (ft-bmp)	Depth to Water (ft-bmp)	LNAPL Thickness (feet)	Groundwater Elevation (ft-amsl)	LNAPL Depth Below Confining Contact (feet)	LNAPL Condition
IEPA-004	Main Sand	C Clay	26.00	430.35	10/1/13	30.80	30.83	0.03	399.52	4.80	Highly Unconfined
					1/14/14	32.71	34.01	1.30	396.34	6.71	Highly Unconfined
					5/13/14	30.51	31.00	0.49	399.35	4.51	Highly Unconfined
					8/4/14	26.65	29.26	2.61	401.09	0.65	Unconfined
					10/27/14	26.40	27.74	1.34	402.61	0.40	Unconfined
					3/4/15	33.61	35.10	1.49	395.25	7.61	Highly Unconfined
					4/7/15	32.53	32.98	0.45	397.37	6.53	Highly Unconfined
					7/20/15	19.37	27.25	7.88	403.10	-6.63	Highly Confined
					10/13/15	28.87	31.24	2.37	399.11	2.87	Unconfined
					1/6/16	20.63	21.96	1.33	408.39	-5.37	Highly Confined
MP-029C	EPA	B Clay	21.5	429.39	9/6/13	--	21.75	--	407.64	0.25	Unconfined
					9/13/13	--	22.30	--	407.09	0.80	Unconfined
					9/23/13	--	22.93	--	406.46	1.43	Unconfined
					9/27/13	--	23.10	--	406.29	1.60	Unconfined
					10/1/13	--	23.25	--	406.14	1.75	Unconfined
					11/14/13	--	23.96	--	405.43	2.46	Unconfined
					12/11/13	24.29	24.30	0.01	405.09	2.80	Unconfined
					1/13/14	--	23.54	--	405.85	2.04	Unconfined
					2/17/14	--	22.04	--	407.35	0.54	Unconfined
					3/20/14	--	24.05	--	405.34	2.55	Unconfined
					4/25/14	--	21.98	--	407.41	0.48	Unconfined
					5/12/14	--	20.80	--	408.59	-0.70	Confined
					6/3/14	19.97	19.98	0.01	409.41	-1.52	Confined
					7/24/14	--	18.85	--	410.54	-2.65	Confined
					8/4/14	--	20.11	--	409.28	-1.39	Confined
					9/8/14	--	19.11	--	410.28	-2.39	Confined

TABLE 4. FLUID LEVELS FOR SELECTED WELLS, MAIN SAND AND EPA STRATA

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Hydro-stratigraphic Unit	Confining Unit	Depth to Bottom of Confining Unit	Measuring Point Elevation	Date	Depth to LNAPL	Depth to Water	LNAPL Thickness	Groundwater Elevation	LNAPL Depth Below Confining Contact	LNAPL Condition
			(ft-bgs)	(ft-amsl)		(ft-bmp)	(ft-bmp)	(feet)	(ft-amsl)	(feet)	
MP-029C	EPA	B Clay	21.5	429.39	10/27/14	--	17.72	--	411.67	-3.78	Confined
					11/20/14	--	20.80	--	408.59	-0.70	Confined
					12/23/14	--	20.13	--	409.26	-1.37	Confined
					1/23/15	--	21.64	--	407.75	0.14	Unconfined
					2/27/15	--	23.23	--	406.16	1.73	Unconfined
					3/5/15	--	23.23	--	406.16	1.73	Unconfined
					4/6/15	--	21.00	--	408.39	-0.50	Confined
					5/12/15	--	21.06	--	408.33	-0.44	Confined
					6/23/15	--	16.98	--	412.41	-4.52	Highly Confined
					7/20/15	--	13.06	--	416.33	-8.44	Highly Confined
					8/24/15	--	17.48	--	411.91	-4.02	Highly Confined
					9/21/15	--	20.68	--	408.71	-0.82	Confined
MP-029D	Main Sand	C Clay	31.80	429.47	9/3/13	29.30	32.60	3.30	396.87	-2.50	Confined
					9/4/13	29.50	32.60	3.10	396.87	-2.30	Confined
					9/5/13	29.60	32.60	3.00	396.87	-2.20	Confined
					9/6/13	29.60	32.60	3.00	396.87	-2.20	Confined
					9/9/13	29.85	32.90	3.05	396.57	-1.95	Confined
					9/10/13	30.00	32.90	2.90	396.57	-1.80	Confined
					9/11/13	30.10	32.80	2.70	396.67	-1.70	Confined
					9/12/13	30.20	32.90	2.70	396.57	-1.60	Confined
					9/13/13	30.30	32.90	2.60	396.57	-1.50	Confined
					9/16/13	30.60	32.80	2.20	396.67	-1.20	Confined
					9/17/13	30.60	32.80	2.20	396.67	-1.20	Confined
					9/23/13	30.80	33.00	2.20	396.47	-1.00	Confined
					9/27/13	31.00	32.90	1.90	396.57	-0.80	Confined
					9/30/13	31.10	33.10	2.00	396.37	-0.70	Confined

TABLE 4. FLUID LEVELS FOR SELECTED WELLS, MAIN SAND AND EPA STRATA

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Hydro-stratigraphic Unit	Confining Unit	Depth to Bottom of Confining Unit (ft-bgs)	Measuring Point Elevation (ft-amsl)	Date	Depth to LNAPL (ft-bmp)	Depth to Water (ft-bmp)	LNAPL Thickness (feet)	Groundwater Elevation (ft-amsl)	LNAPL Depth Below Confining Contact (feet)	LNAPL Condition
MP-029D	Main Sand	C Clay	31.80	429.47	10/1/13	31.22	31.23	0.01	398.24	-0.58	Confined
					1/13/14	33.30	35.55	2.25	393.92	1.50	Unconfined
					5/12/14	30.73	31.47	0.74	398.00	-1.07	Confined
					8/4/14	26.70	32.17	5.47	397.30	-5.10	Highly Confined
					10/27/14	25.58	32.32	6.74	397.15	-6.22	Highly Confined
					3/5/15	34.25	36.87	2.62	392.60	2.45	Unconfined
					4/6/15	33.15	33.20	0.05	396.27	1.35	Unconfined
					7/20/15	18.31	32.13	13.82	397.34	-13.49	Highly Confined
					10/13/15	29.41	32.54	3.13	396.93	-2.39	Confined
					1/7/16	19.39	29.91	10.52	399.56	-12.41	Highly Confined
MP-037D	Main Sand	C Clay	30.50	429.04	9/4/13	29.19	29.51	0.32	399.53	-1.31	Confined
					10/1/13	30.46	31.40	0.94	397.64	-0.04	Confined
					1/14/14	32.66	33.82	1.16	395.22	2.16	Unconfined
					5/13/14	--	30.28	--	398.76	--	--
					8/4/14	25.91	30.51	4.60	398.53	-4.59	Highly Confined
					10/27/14	--	26.45	--	402.59	--	--
					3/4/15	33.45	35.60	2.15	393.44	2.95	Unconfined
					4/7/15	32.44	32.60	0.16	396.44	1.94	Unconfined
					7/20/15	18.42	28.50	10.08	400.54	-12.08	Highly Confined
					10/13/15	29.07	29.29	0.22	399.75	-1.43	Confined
					1/7/16	18.29	29.43	11.14	399.61	-12.21	Highly Confined
MP-042C	Main Sand	C Clay	31.00	430.32	9/5/13	30.20	31.00	0.80	399.32	-0.80	Confined
					9/9/13	30.50	31.30	0.80	399.02	-0.50	Confined
					9/10/13	30.71	31.06	0.35	399.26	-0.29	Confined

TABLE 4. FLUID LEVELS FOR SELECTED WELLS, MAIN SAND AND EPA STRATA

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Hydro-stratigraphic Unit	Confining Unit	Depth to Bottom of Confining Unit (ft-bgs)	Measuring Point Elevation (ft-amsl)	Date	Depth to LNAPL (ft-bmp)	Depth to Water (ft-bmp)	LNAPL Thickness (feet)	Groundwater Elevation (ft-amsl)	LNAPL Depth Below Confining Contact (feet)	LNAPL Condition
MP-042C	Main Sand	C Clay	31.00	430.32	9/12/13	30.80	31.20	0.40	399.12	-0.20	Confined
					9/26/13	31.50	32.00	0.50	398.32	0.50	Unconfined
					10/1/13	31.65	32.20	0.55	398.12	0.65	Unconfined
					11/14/13	32.32	32.88	0.56	397.44	1.32	Unconfined
					12/11/13	33.00	33.81	0.81	396.51	2.00	Unconfined
					1/14/14	33.80	34.67	0.87	395.65	2.80	Unconfined
					2/17/14	34.24	35.31	1.07	395.01	3.24	Unconfined
					3/20/14	33.86	34.66	0.80	395.66	2.86	Unconfined
					4/25/14	--	32.30	--	398.02	--	--
					5/13/14	--	31.45	--	398.87	--	--
					6/3/14	30.20	30.60	0.40	399.72	-0.80	Confined
					7/24/14	25.00	29.85	4.85	400.47	-6.00	Highly Confined
					8/4/14	26.62	29.74	3.12	400.58	-4.38	Highly Confined
					9/8/14	28.72	30.71	1.99	399.61	-2.28	Confined
					10/27/14	--	27.50	--	402.82	--	--
					11/20/14	--	30.73	--	399.59	--	--
					12/23/14	31.98	32.22	0.24	398.10	0.98	Unconfined
					1/23/15	33.63	34.03	0.40	396.29	2.63	Unconfined
					2/27/15	34.55	36.10	1.55	394.22	3.55	Unconfined
					3/9/15	34.55	36.10	1.55	394.22	3.55	Unconfined
					4/6/15	33.52	33.82	0.30	396.50	2.52	Unconfined
					5/12/15	32.41	32.55	0.14	397.77	1.41	Unconfined
					6/23/15	23.51	27.23	3.72	403.09	-7.49	Highly Confined
					7/20/15	--	21.07	--	409.25	--	--
					8/24/15	27.00	27.32	0.32	403.00	-4.00	Highly Confined
					9/21/15	29.07	29.08	0.01	401.24	-1.93	Confined
					10/13/15	30.28	30.66	0.38	399.66	-0.72	Confined

TABLE 4. FLUID LEVELS FOR SELECTED WELLS, MAIN SAND AND EPA STRATA

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Hydro-stratigraphic Unit	Confining Unit	Depth to Bottom of Confining Unit (ft-bgs)	Measuring Point Elevation (ft-amsl)	Date	Depth to LNAPL (ft-bmp)	Depth to Water (ft-bmp)	LNAPL Thickness (feet)	Groundwater Elevation (ft-amsl)	LNAPL Depth Below Confining Contact (feet)	LNAPL Condition
MP-042C	Main Sand	C Clay	31.00	430.32	11/16/15	31.45	32.53	1.08	397.79	0.45	Unconfined
					12/14/15	--	29.19	--	401.13	--	--
					1/6/16	19.33	29.42	10.09	400.90	-11.67	Highly Confined
RW-004A	Multiple Strata	C Clay	34.00	429.86	9/4/13	29.70	32.60	2.90	397.26	-4.30	Highly Confined
					9/11/13	30.40	32.60	2.20	397.26	-3.60	Confined
					9/24/13	31.10	32.70	1.60	397.16	-2.90	Confined
					9/30/13	31.40	32.70	1.30	397.16	-2.60	Confined
					10/1/13	31.56	32.81	1.25	397.05	-2.44	Confined
					1/13/14	33.72	34.90	1.18	394.96	-0.28	Confined
					5/13/14	31.00	31.95	0.95	397.91	-3.00	Confined
					8/4/14	27.03	31.99	4.96	397.87	-6.97	Highly Confined
					10/27/14	25.98	32.00	6.02	397.86	-8.02	Highly Confined
					3/9/15	--	34.48	--	395.38	--	--
					4/7/15	33.47	33.86	0.39	396.00	-0.53	Confined
					7/20/15	20.64	24.95	4.31	404.91	-13.36	Highly Confined
					10/13/15	29.83	32.30	2.47	397.56	-4.17	Highly Confined
					1/6/16	20.40	25.74	5.34	404.12	-13.60	Highly Confined
RW-005	Multiple Strata	C Clay	31.00	430.22	9/4/13	29.95	30.24	0.29	399.98	-1.05	Confined
					9/11/13	30.50	30.70	0.20	399.52	-0.50	Confined
					9/24/13	31.10	31.40	0.30	398.82	0.10	Unconfined
					9/30/13	31.30	31.60	0.30	398.62	0.30	Unconfined
					10/1/13	31.38	31.71	0.33	398.51	0.38	Unconfined
					1/14/14	33.50	34.22	0.72	396.00	2.50	Unconfined
					5/13/14	31.18	31.28	0.10	398.94	0.18	Unconfined
					8/4/14	27.18	30.10	2.92	400.12	-3.82	Confined

TABLE 4. FLUID LEVELS FOR SELECTED WELLS, MAIN SAND AND EPA STRATA

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Hydro-stratigraphic Unit	Confining Unit	Depth to Bottom of Confining Unit	Measuring Point Elevation	Date	Depth to LNAPL	Depth to Water	LNAPL Thickness	Groundwater Elevation	LNAPL Depth Below Confining Contact	LNAPL Condition
			(ft-bgs)	(ft-amsl)		(ft-bmp)	(ft-bmp)	(feet)	(ft-amsl)	(feet)	
RW-005	Multiple Strata	C Clay	31.00	430.22	10/28/14	26.87	30.17	3.30	400.05	-4.13	Highly Confined
					3/6/15	34.28	35.48	1.20	394.74	3.28	Unconfined
					4/6/15	33.20	33.45	0.25	396.77	2.20	Unconfined
					7/20/15	19.12	30.45	11.33	399.77	-11.88	Highly Confined
					10/13/15	29.91	30.59	0.68	399.63	-1.09	Confined
					1/6/16	18.81	30.68	11.87	399.54	-12.19	Highly Confined

Notes:

ft-bgs - feet below ground surface
ft-amsl - feet above mean sea level
ft-bmp - feet below measuring point

TABLE 5. DISSOLVED PHASE ANALYTICAL RESULTS SUMMARY

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Hydrostratigraphic Unit	Date	Benzene	Ethylbenzene	Toluene	Xylenes, Total	MTBE	Arsenic	Lead
			(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
HMW-048A	North Olive	6/27/14	2.8	4.2	0.12	11	ND(0.10)	0.31	0.37
		6/25/15	1.2	4.0 J-	0.071 J-	8.8	ND(0.040)	--	--
MP-042B	Rand	6/30/14	2.3	0.54	ND(0.10)	2.3	--	0.011	ND(0.0069)
MP-085A	North Olive	9/11/14	ND(0.0020)	ND(0.0010)	ND(0.0010)	ND(0.0010)	ND(0.0020)	0.063	ND(0.0069)
MP-085B	Rand	11/21/13	ND(0.0020)	ND(0.0010)	ND(0.0010)	ND(0.0011) UJ	ND(0.0020)	0.028	0.0062 J
MP-085C	EPA	11/21/13	0.054	2.6	0.24	6.7	ND(0.040)	0.0025 J	0.013

Notes:

MTBE - methyl tert-buytl ether

mg/L - milligrams per liter

ND - non-detect at the indicated reporting limit in parenthesis

J - estimated concentration

J- - estimated concentration may be biased low

UJ - estimated concentration below the reporting limit

TABLE 6. SUMMARY OF SVE EFFECTIVENESS MONITORING RESULTS

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Well Diameter	Subsurface Layer	Date	Static Pressure/ Vacuum	Estimated Soil Gas Permeability	Probe Specific Capacity	Oxygen	Carbon Dioxide	Lower Explosive Level	Methane	Total Hydrocarbons	Petroleum Hydrocarbons	Volatile Organic Chemicals
	(inches)			(in-H_2O)	(cm^2)	($cm^3/s{\cdot}in\ H_2O$)	(%)	(%)	(%)	(ppmv)	(ppmv)	(ppmv)	(ppmv)
MP-029A	1.00	N Olive	5/10/15	-0.06	1.17E-08	-12.23	6.8	8.2	100	23,070	51,930	28,860	31.9
			9/3/15	-0.37	1.44E-08	-15.1	0.0	15.1	100	371,000	654,000	283,000	43.1
			11/17/15	0.00	1.91E-08	-20.00	0.1	16.0	100	330,000	420,000	90,000	26.0
			2/5/16	-0.35	1.45E-08	-15.21	3.3	11.0	100	373,000	590,000	217,000	48.5
MP-037A	1.00	N Olive	5/10/15	0.00	4.60E-09	-12.06	10.5	2.0	0	4.50	10.7	6.20	0.16
			9/3/15	0.00	3.52E-10	-0.96	6.3	2.7	0	18.9	28.2	9.30	0.00
			11/17/15	0.08	1.18E-09	-3.12	0.6	6.8	0	6.00	11.0	5.00	0.00
			2/5/16	-0.17	1.41E-09	-3.72	14.8	1.7	0	0.00	0.00	0.00	0.00
MP-041A	1.00	N Olive	5/10/15	0.00	1.09E-08	-11.40	20.2	0.2	0	46.5	91.2	44.7	10.5
			9/4/15	0.00	3.07E-09	-3.25	9.7	4.2	0	9.00	26.0	17.0	0.00
			11/17/15	0.14	4.50E-09	-4.76	4.3	7.0	0	0.00	0.00	0.00	0.00
			2/5/16	-0.18	5.22E-09	-5.50	12.6	3.7	0	30.0	65.0	35.0	0.00
MP-042A	1.00	N Olive	5/10/15	0.00	4.14E-09	-19.36	14.4	6.7	0	0.00	0.00	0.00	0.00
			9/3/15	0.00	1.06E-08	-55.5	4.4	11.6	0	0.00	0.00	0.00	0.00
			11/17/15	0.00	1.20E-08	-62.81	10.0	11.6	0	0.00	40.0	40.0	0.00
			2/5/16	-0.19	4.77E-09	-23.39	2.8	10.0	0	0.00	0.00	0.00	0.00
MP-085A	1.00	N Olive	11/17/15	0.00	1.98E-07	-52.83	20.5	0.0	0	84.3	92.0	7.71	1.00
MP-116S	0.50	N Olive	5/11/15	0.00	2.44E-09	-1.03	13.2	10.5	100	21,000	34,000	13,000	81.1
			9/2/15	0.00	3.50E-09	-1.51	15.7	7.8	1	11,500	23,000	11,500	160
			11/18/15	0.00	3.60E-09	-1.55	4.9	18.5	100	85,000	160,000	75,000	342
			2/7/16	0.00	1.05E-09	-0.48	--	--	--	--	--	--	--
MP-117S	0.50	N Olive	5/11/15	0.00	9.24E-10	-0.40	13.6	8.4	100	27,000	39,000	12,000	46.5
			11/18/15	0.00	5.30E-09	-2.26	0.9	26.2	100	80,000	185,000	105,000	301

TABLE 6. SUMMARY OF SVE EFFECTIVENESS MONITORING RESULTS

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Well Diameter	Subsurface Layer	Date	Static Pressure/ Vacuum	Estimated Soil Gas Permeability	Probe Specific Capacity	Oxygen	Carbon Dioxide	Lower Explosive Level	Methane	Total Hydrocarbons	Petroleum Hydrocarbons	Volatile Organic Chemicals
	(inches)			(in-H_2O)	(cm^2)	(cm^3/s·in H_2O)	(%)	(%)	(%)	(ppmv)	(ppmv)	(ppmv)	(ppmv)
MP-118S	0.50	N Olive	5/11/15	0.00	1.17E-09	-0.50	19.1	0.9	0	1,776	2,200	424	63.4
			11/18/15	0.00	2.75E-09	-1.19	11.0	9.4	50	55,000	75,000	20,000	16.0
			2/7/16	0.07	1.90E-09	-0.84	--	--	--	--	--	--	--
MP-120S	0.50	N Olive	5/11/15	0.00	1.12E-09	-0.48	11.1	5.0	100	100,000	145,000	45,000	9.62
			11/19/15	0.00	5.31E-09	-2.26	11.3	6.5	100	115,000	150,000	35,000	8.00
MP-121S	0.50	N Olive	5/11/15	0.00	2.65E-09	-1.12	19.9	0.6	0	80.6	392	311	48.9
			9/3/15	0.00	9.65E-09	-4.08	11.0	7.9	8	100,000	128,000	28,000	0.00
			11/18/15	0.00	6.14E-09	-2.61	13.8	7.1	9	10,500	13,500	3,000	1.00
			2/7/16	0.00	1.77E-08	-7.44	--	--	--	--	--	--	--
MP-122S	0.50	N Olive	5/11/15	-1.27	2.25E-09	-0.95	20.4	0.3	0	7.55	192	184	29.0
			9/3/15	0.00	3.03E-08	-12.7	14.7	1.1	1	1,510	2,130	620	1.96
			11/18/15	0.00	3.85E-08	-16.18	18.0	1.0	0	0.00	13.0	13.0	5.00
			2/7/16	0.00	3.92E-09	-1.68	20.9	0.0	0	0.00	136	136	31.5
MP-123S	0.50	N Olive	5/11/15	-0.75	3.22E-09	-1.36	19.7	0.8	0	0.00	159	159	25.5
			9/3/15	0.00	4.94E-08	-20.8	10.7	4.8	0	12.0	26.4	14.4	0.00
			11/18/15	-0.08	7.48E-08	-31.36	18.2	4.5	0	0.00	8.00	8.00	4.00
			2/7/16	0.00	3.94E-09	-1.69	20.9	0.0	0	0.00	154	154	44.0
MP-124S	0.50	N Olive	5/11/15	0.00	2.02E-09	-0.86	19.1	0.1	0	23.7	155	131	23.5
			9/3/15	0.00	9.65E-09	-4.08	15.1	2.0	0	48.9	94.9	46.0	0.00
			11/18/15	-0.09	5.49E-09	-2.34	14.1	3.2	0	0.00	0.00	0.00	0.00
			2/7/16	0.08	1.53E-09	-0.68	--	--	--	--	--	--	--
MP-124M	0.50	N Olive	5/11/15	0.07	1.00E-09	-0.43	20.2	0.4	0	6.73	117	110	19.0
			11/18/15	0.00	7.15E-09	-3.04	20.2	0.0	0	0.00	18.0	18.0	6.00
			2/7/16	0.06	3.64E-09	-1.57	--	--	--	--	--	--	--

TABLE 6. SUMMARY OF SVE EFFECTIVENESS MONITORING RESULTS

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Well Diameter	Subsurface Layer	Date	Static Pressure/ Vacuum	Estimated Soil Gas Permeability	Probe Specific Capacity	Oxygen	Carbon Dioxide	Lower Explosive Level	Methane	Total Hydrocarbons	Petroleum Hydrocarbons	Volatile Organic Chemicals
	(inches)			(in-H_2O)	(cm^2)	(cm^3/s·in H_2O)	(%)	(%)	(%)	(ppmv)	(ppmv)	(ppmv)	(ppmv)
MP-125S	0.50	N Olive	5/11/15	0.00	2.36E-09	-1.00	19.1	1.1	0	1,054	1,600	546	49.9
			9/3/15	0.00	2.31E-08	-9.72	9.6	2.8	0	0.00	13.0	13.0	0.00
			11/18/15	0.00	1.23E-08	-5.21	11.6	3.1	0	0.00	13.0	13.0	0.00
			2/7/16	0.00	1.67E-08	-7.04	11.8	2.5	0	0.00	55.0	55.0	0.50
MP-126S	0.50	N Olive	9/3/15	0.00	9.65E-09	-4.08	13.8	0.7	0	24.0	33.0	9.00	0.00
			11/18/15	-0.06	3.42E-09	-1.47	17.3	0.3	0	0.00	4.00	4.00	1.70
			2/7/16	-0.08	2.41E-08	-10.14	19.6	0.4	0	0.00	19.0	19.0	4.00
MP-126M	0.50	N Olive	5/11/15	0.00	1.43E-09	-0.61	20.5	0.2	0	16.2	97.1	80.9	16.1
			11/18/15	0.00	3.60E-09	-1.55	18.7	0.3	0	0.00	6.00	6.00	2.50
			2/7/16	0.15	3.05E-09	-1.32	--	--	--	--	--	--	--
			5/11/15	-0.77	2.90E-09	-1.23	20.7	0.2	0	11.2	109	97.8	17.8
MP-127S	0.50	N Olive	5/11/15	0.00	2.90E-09	-1.22	18.1	0.6	0	122	226	104	17.8
			9/4/15	0.00	1.59E-08	-6.72	17.3	1.1	0	10.9	46.1	35.2	19.3
			11/19/15	-0.06	8.36E-09	-3.54	18.8	0.5	0	2.78	7.00	4.22	2.00
			2/7/16	0.00	2.43E-08	-10.21	18.9	0.6	0	5.97	350	344	83.0
MP-127M	0.50	N Olive	5/11/15	-0.13	2.50E-09	-1.06	14.4	1.9	0	0.00	77.2	77.2	1.77
			9/4/15	-0.12	2.01E-08	-8.47	15.9	2.1	0	143	337	194	3.74
			11/19/15	-0.11	6.19E-09	-2.64	16.9	1.6	0	1.39	8.00	6.61	3.00
			2/7/16	0.00	2.49E-08	-10.47	16.1	1.6	0	62.2	587	525	118
MP-127D	0.50	Rand	5/11/15	-0.32	2.46E-09	-1.04	0.9	16.2	100	96,000	165,000	69,000	57.9
			9/4/15	-0.41	1.91E-08	-8.05	0.6	17.2	15	157,000	225,000	68,000	145
			11/19/15	-0.62	1.97E-08	-8.31	0.7	17.2	100	100,000	165,000	65,000	205
			2/7/16	-0.12	3.07E-08	-12.89	2.7	15.7	100	478,000	583,000	105,000	185
VMP-012S	0.125	N Olive	5/8/15	--	6.37E-09	-1.19	4.9	7.9	100	560,000	1,000,000	440,000	5.90

TABLE 6. SUMMARY OF SVE EFFECTIVENESS MONITORING RESULTS

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Well Diameter	Subsurface Layer	Date	Static Pressure/ Vacuum	Estimated Soil Gas Permeability	Probe Specific Capacity	Oxygen	Carbon Dioxide	Lower Explosive Level	Methane	Total Hydrocarbons	Petroleum Hydrocarbons	Volatile Organic Chemicals
	(inches)			(in-H_2O)	(cm^2)	(cm^3/s·in H_2O)	(%)	(%)	(%)	(ppmv)	(ppmv)	(ppmv)	(ppmv)
VMP-064VS	0.125	A Clay	5/8/15	0.26	8.70E-09	-1.62	1.4	8.7	0	0.00	0.00	0.00	0.00
			9/4/15	-0.14	1.12E-08	-2.08	0.1	13.9	0	82.4	170	87.2	3.61
			11/14/15	0.00	5.02E-09	-0.94	3.4	8.4	0	0.00	245	245	9.50
			2/3/16	-0.11	6.17E-09	-1.15	4.9	5.5	0	93.4	640	547	8.50
VMP-064S	0.125	N Olive	5/8/15	-0.19	8.77E-10	-0.17	1.5	3.5	0	0.00	0.00	0.00	0.20
			9/4/15	-0.49	5.73E-09	-1.07	1.1	7.1	0	121	518	396	10.1
			11/14/15	0.00	1.79E-09	-0.34	1.6	7.6	0	26.0	168	142	6.55
VMP-064M	0.125	N Olive	5/8/15	-0.16	4.00E-09	-0.75	0.5	3.5	100	2,400	42,000	39,600	362
			9/4/15	-0.50	4.02E-09	-0.75	2.7	4.5	33	2,960	49,780	46,820	509
			11/14/15	0.00	3.72E-09	-0.69	2.5	5.1	43	5,420	64,250	58,830	501
VMP-090VS	0.125	A Clay	5/8/15	-1.65	3.40E-09	-0.64	4.2	2.9	0	75.0	134	59.2	0.30
			9/3/15	0.00	8.80E-10	-0.17	2.5	5.9	0	6.50	56.4	49.9	0.00
VP-004S	0.125	N Olive	5/12/15	0.00	3.95E-09	-0.74	4.4	5.0	0	0.00	0.00	0.00	0.00
			11/15/15	0.00	1.47E-09	-0.28	0.8	8.4	73	70,300	110,000	39,700	47.5
			2/3/16	0.00	2.99E-09	-0.56	6.3	5.6	100	105,000	105,000	0.00	31.0

Notes:

-- - not applicable
in-H_2O - inches of water
cm^2 - square centimeters
cm^3/s·in H_2O - cubic centimeters per second per inch of water
% - percent
ppmv - parts per million by volume

TABLE 7. SUMMARY OF ENHANCED TOTAL PHASE EXTRACTION TEST RESULTS

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Date	Top of Screen	Bottom of Screen	Depth to Water*	Stinger Depth	Open Screen	Water Generation Rate	Water Generation Rate	Air Flow Rate	Air Flowrate Measurement Device	TVPH	Mass Removal Rate
		(ft-btoc)	(ft-btoc)	(ft-btoc)	(ft-btoc)	(feet)	(gpm)	(gpd)	(scfm)		(ppmv)	(lb/day)
SOIL VAPOR EXTRACTION WELLS												
HSVE-057	2/23/2016	20.46	27.07	9.70	--	--	--	--	--	--	--	--
	3/1/2016	20.46	27.07	--	22.55	--	0.88	1,267	0.00	Dwyer (0-100 scfm)	--	--
	3/2/2016	20.46	27.07	--	22.55	--	0.58	834	0.00	Dwyer (0-100 scfm)	--	--
	3/3/2016	20.46	27.07	--	22.55	--	0.52	754	0.00	Dwyer (0-100 scfm)	--	--
	3/4/2016	20.46	27.07	--	23.55	--	0.57	814	0.00	Dwyer (0-100 scfm)	--	--
	3/7/2016	20.46	27.07	24.70	23.55	4.24	0.61	873	0.00	Dwyer (0-50 scfm)	11.0	0.00
	3/8/2016	20.46	27.07	24.70	23.55	4.24	0.59	853	1.00	Dwyer (0-50 scfm)	--	--
	3/8/2016	20.46	27.07	24.70	23.55	4.24	0.59	853	4.30	Preso	71.0	0.10
	3/9/2016	20.46	27.07	24.70	23.55	4.24	0.59	853	3.57	Preso	36.0	0.04
	3/10/2016	20.46	27.07	--	23.55	--	0.59	853	3.57	Preso	34.0	0.04
	3/11/2016	20.46	27.07	--	23.55	--	0.47	675	3.60	Preso	--	--
HSVE-059	2/23/2016	17.54	25.11	8.45	--	--	--	--	--	--	--	--
	3/1/2016	17.54	25.11	--	20.40	--	0.27	391	0.00	Dwyer (0-100 scfm)	--	--
	3/2/2016	17.54	25.11	--	20.40	--	0.52	754	0.00	Dwyer (0-100 scfm)	--	--
	3/3/2016	17.54	25.11	--	20.40	--	0.48	695	0.00	Dwyer (0-100 scfm)	--	--
	3/4/2016	17.54	25.11	--	21.50	--	0.50	714	15.0	Dwyer (0-100 scfm)	--	--
	3/7/2016	17.54	25.11	22.28	21.50	4.74	0.45	655	0.00	Dwyer (0-50 scfm)	1,367	0.00
	3/8/2016	17.54	25.11	22.28	21.50	4.74	0.73	1,052	1.00	Dwyer (0-50 scfm)	--	--
	3/8/2016	17.54	25.11	22.28	21.50	4.74	0.73	1,052	2.69	Preso	4,035	3.55
	3/9/2016	17.54	25.11	22.30	21.50	4.76	0.44	635	1.78	Preso	180	0.10
	3/10/2016	17.54	25.11	--	21.50	--	0.47	675	1.35	Preso	170	0.08
	3/11/2016	17.54	25.11	--	21.50	--	0.36	516	1.51	Preso	--	-

TABLE 7. SUMMARY OF ENHANCED TOTAL PHASE EXTRACTION TEST RESULTS

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Date	Top of Screen	Bottom of Screen	Depth to Water*	Stinger Depth	Open Screen	Water Generation Rate	Water Generation Rate	Air Flow Rate	Air Flowrate Measurement Device	TVPH	Mass Removal Rate
		(ft-btoc)	(ft-btoc)	(ft-btoc)	(ft-btoc)	(feet)	(gpm)	(gpd)	(scfm)		(ppmv)	(lb/day)
HSVE-060	2/23/2016	17.83	24.31	9.45	--	--	--	--	--	--	--	--
	3/1/2016	17.83	24.31	--	22.55	--	0.14	204	0.00	Dwyer (0-100 scfm)	--	--
	3/2/2016	17.83	24.31	--	22.55	--	0.33	476	0.00	Dwyer (0-100 scfm)	--	--
	3/3/2016	17.83	24.31	--	22.55	--	0.26	377	0.00	Dwyer (0-100 scfm)	--	--
	3/4/2016	17.83	24.31	--	20.60	--	0.29	417	0.00	Dwyer (0-100 scfm)	--	--
	3/7/2016	17.83	24.31	21.26	20.60	3.43	0.29	417	0.00	Dwyer (0-50 scfm)	4.00	0.00
	3/8/2016	17.83	24.31	21.26	20.60	3.43	0.29	417	1.00	Dwyer (0-50 scfm)	--	--
	3/8/2016	17.83	24.31	21.26	20.60	3.43	0.29	417	1.20	Preso	2.00	0.00
	3/9/2016	17.83	24.31	21.30	20.60	3.47	0.26	377	0.69	Preso	160	0.04
	3/10/2016	17.83	24.31	--	20.60	--	0.30	437	1.16	Preso	0.00	0.00
	3/11/2016	17.83	24.31	--	20.60	--	0.22	318	0.83	Preso	--	--
MONITORING WELLS												
HMW-004	3/1/2016	21.02	25.75	9.92	--	--	--	--	--	--	--	--
	3/2/2016	21.02	25.75	11.30	--	--	--	--	--	--	--	--
	3/3/2016	21.02	25.75	11.57	--	--	--	--	--	--	--	--
	3/4/2016	21.02	25.75	12.01	--	--	--	--	--	--	--	--
	3/7/2016	21.02	25.75	12.53	--	--	--	--	--	--	--	--
	3/8/2016	21.02	25.75	12.84	--	--	--	--	--	--	--	--
	3/8/2016	21.02	25.75	12.84	--	--	--	--	--	--	--	--
	3/9/2016	21.02	25.75	13.00	--	--	--	--	--	--	--	--
	3/10/2016	21.02	25.75	13.15	--	--	--	--	--	--	--	--
	3/11/2016	21.02	25.75	13.42	--	--	--	--	--	--	--	--

TABLE 7. SUMMARY OF ENHANCED TOTAL PHASE EXTRACTION TEST RESULTS

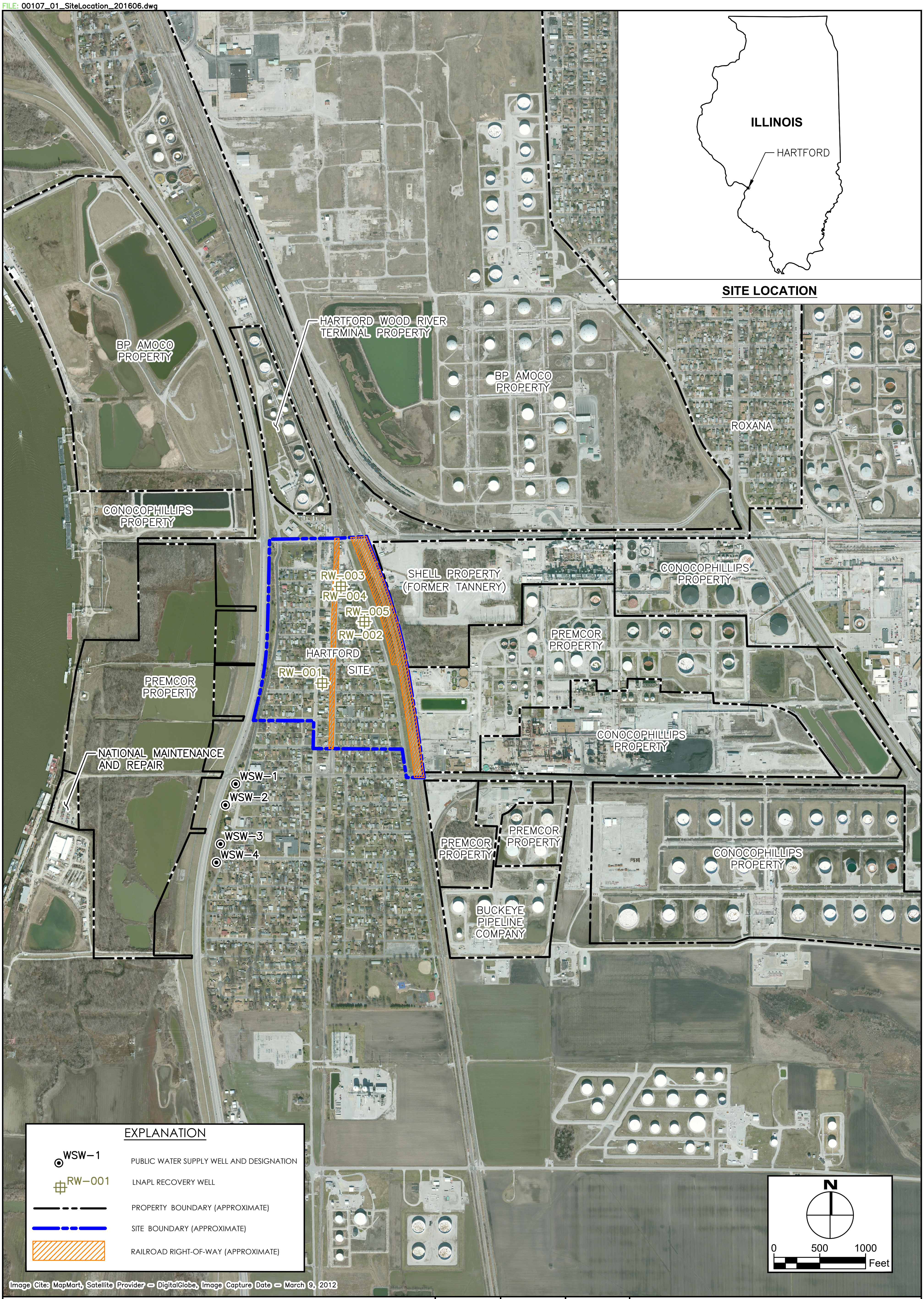
HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Date	Top of Screen	Bottom of Screen	Depth to Water*	Stinger Depth	Open Screen	Water Generation Rate	Water Generation Rate	Air Flow Rate	Air Flowrate Measurement Device	TVPH	Mass Removal Rate
		(ft-btoc)	(ft-btoc)	(ft-btoc)	(ft-btoc)	(feet)	(gpm)	(gpd)	(scfm)		(ppmv)	(lb/day)
HMW-048B	3/1/2016	20.50	29.20	11.21	--	--	--	--	--	--	--	--
	3/2/2016	20.50	29.20	11.04	--	--	--	--	--	--	--	--
	3/3/2016	20.50	29.20	11.42	--	--	--	--	--	--	--	--
	3/4/2016	20.50	29.20	11.55	--	--	--	--	--	--	--	--
	3/7/2016	20.50	29.20	12.12	--	--	--	--	--	--	--	--
	3/8/2016	20.50	29.20	11.80	--	--	--	--	--	--	--	--
	3/8/2016	20.50	29.20	11.80	--	--	--	--	--	--	--	--
	3/9/2016	20.50	29.20	11.92	--	--	--	--	--	--	--	--
	3/10/2016	20.50	29.20	12.10	--	--	--	--	--	--	--	--
	3/11/2016	20.50	29.20	12.32	--	--	--	--	--	--	--	--
MP-085B	3/1/2016	14.20	23.70	7.95	--	--	--	--	--	--	--	--
	3/2/2016	14.20	23.70	8.10	--	--	--	--	--	--	--	--
	3/3/2016	14.20	23.70	8.10	--	--	--	--	--	--	--	--
	3/4/2016	14.20	23.70	8.25	--	--	--	--	--	--	--	--
	3/7/2016	14.20	23.70	8.55	--	--	--	--	--	--	--	--
	3/8/2016	14.20	23.70	8.70	--	--	--	--	--	--	--	--
	3/8/2016	14.20	23.70	8.70	--	--	--	--	--	--	--	--
	3/9/2016	14.20	23.70	8.82	--	--	--	--	--	--	--	--
	3/10/2016	14.20	23.70	8.95	--	--	--	--	--	--	--	--
	3/11/2016	14.20	23.70	9.16	--	--	--	--	--	--	--	--

Notes:
* The fluid level measurements collected from the operating extraction wells are considered qualitative as the vacuum is disrupted prior to gauging.
ft-btoc - feet below top of casing
gpm - gallons per minute
gpd - gallons per day
scfm - standard cubic feet per minute
ppmv - parts per million by volume
lb/day - pounds per day
-- not measured

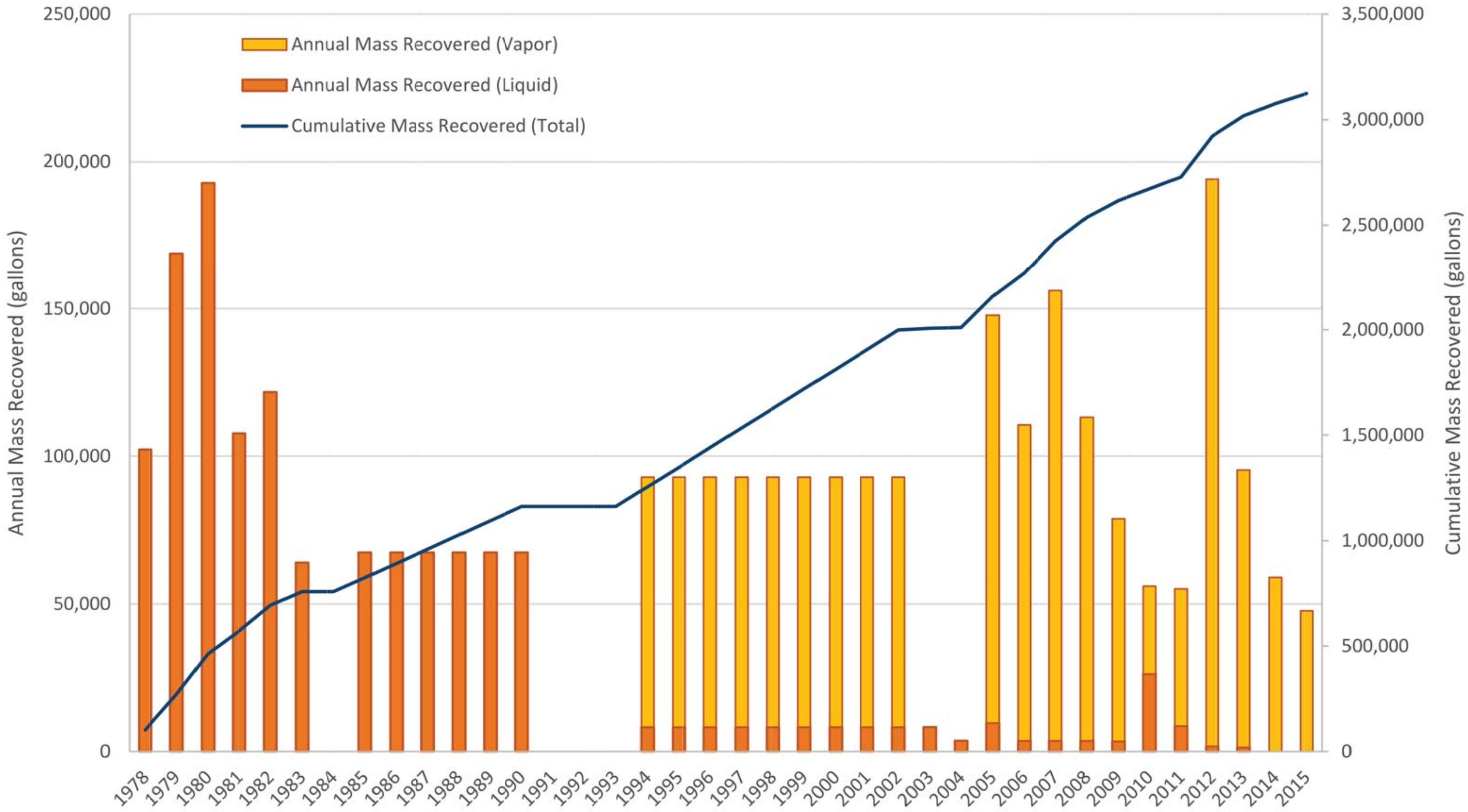
FIGURES

FILE: 00107_01_SiteLocation_201606.dwg



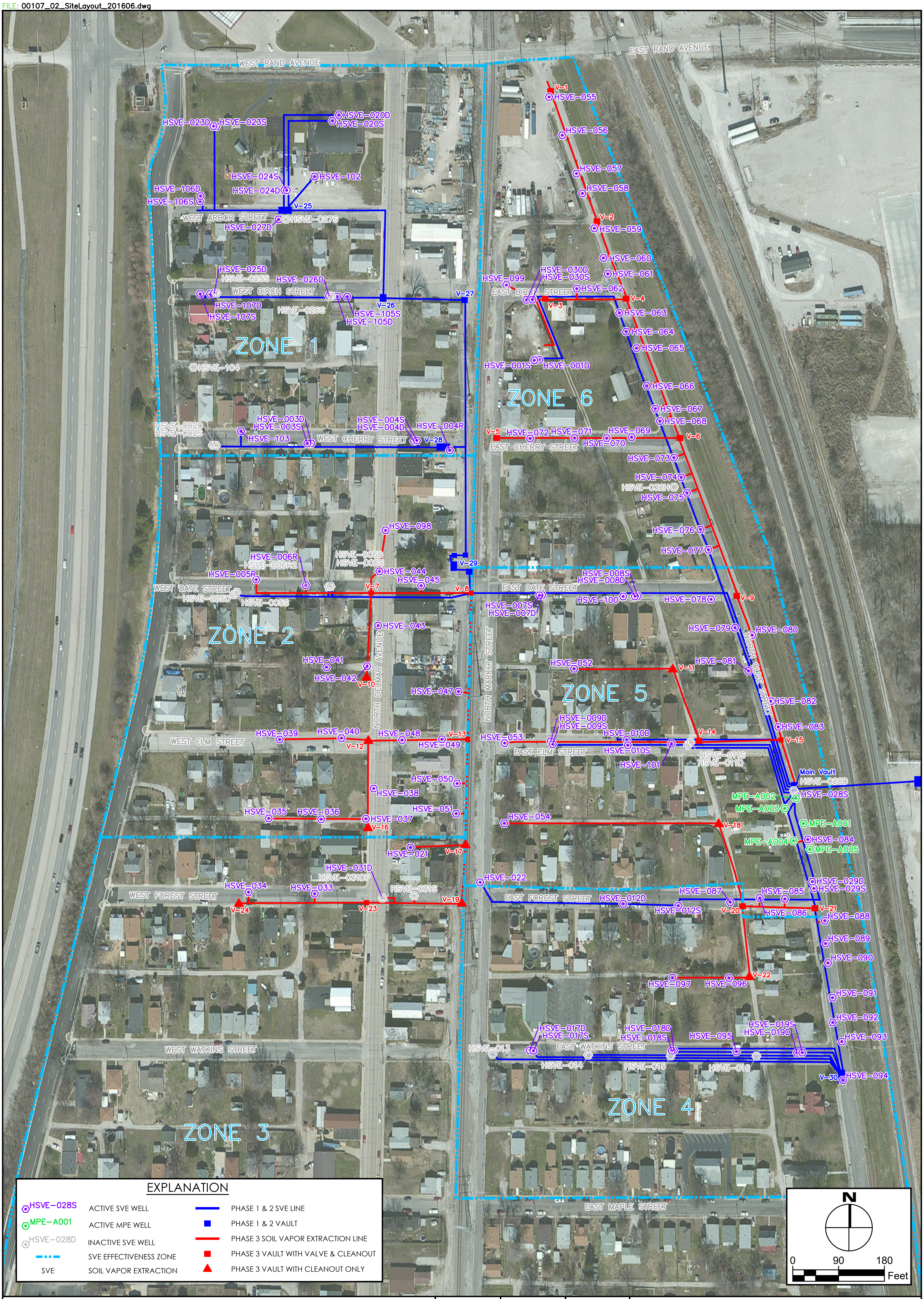
TITLE: FIGURE 1. SITE LOCATION	1" = 1000' (SCALE.)	16-001-07 (PROJECT NO.)	08/26/16 (DATE.)	TWO ONE TWO ENVIRONMENTAL 816 Delta Avenue Cincinnati, Ohio 45226 (513) 430-1766
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS	JGP (DRAWN.)	PEM (CHECKED.)	REV. 0 (REVISION.)	

FILE: 00107_02_RecoveryOverTime_201606.dwg



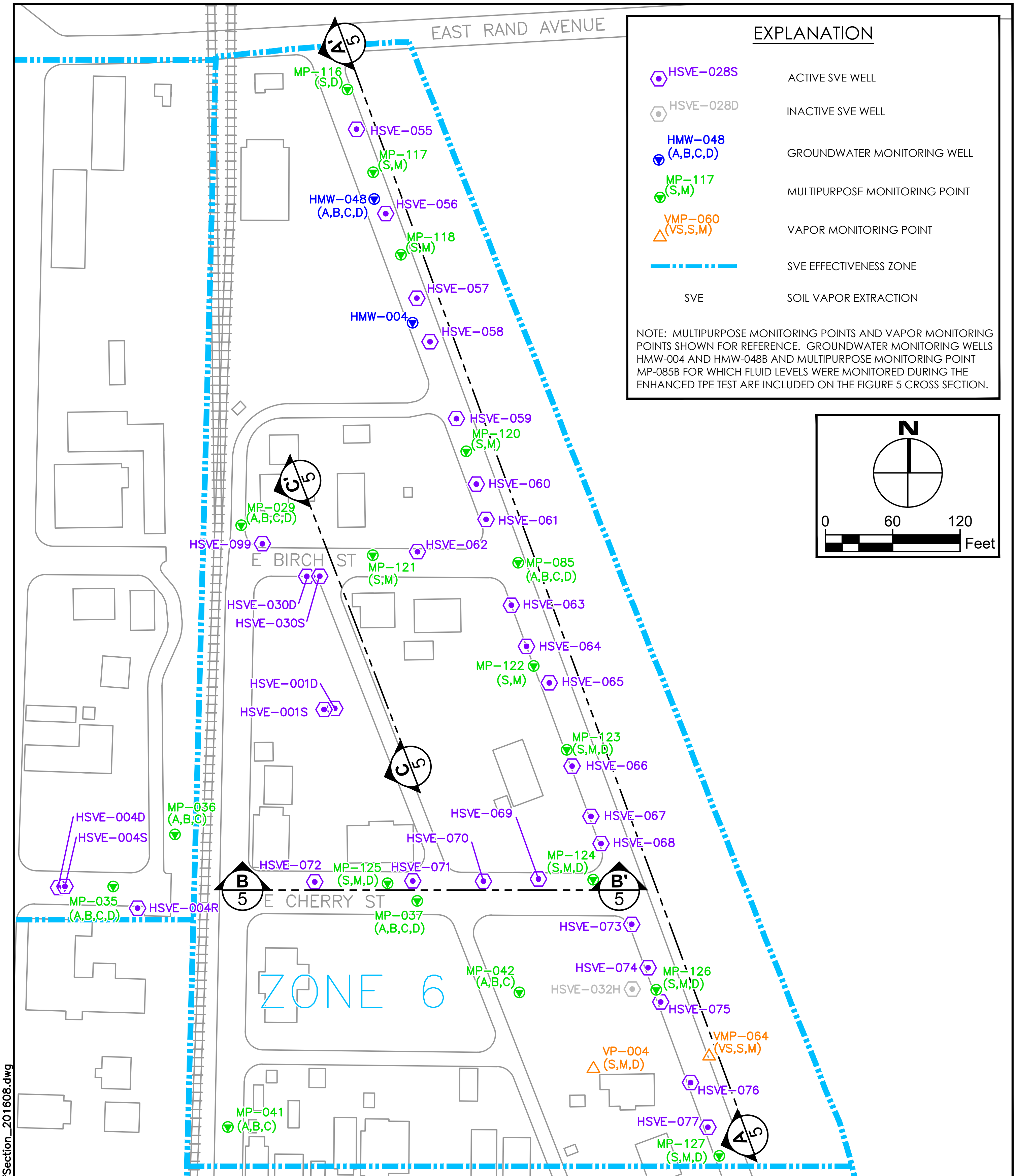
TITLE: FIGURE 2. PETROLEUM RECOVERED SINCE 1986	NO SCALE (SCALE.)	16-001-07 (PROJECT NO.)	06/19/16 (DATE.)	TWO ONE TWO ENVIRONMENTAL
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS	JGP (DRAWN.)	PEM (CHECKED.)	REV. 0 (REVISION.)	816 Delta Avenue Cincinnati, Ohio 45226 (513) 430-1766

FILE: 00107_02_SiteLayout_201606.dwg



TITLE: FIGURE 3. HARTFORD VAPOR COLLECTION SYSTEM LAYOUT	1" = 180' SCALE.	16-001-05 PROJECT NO.	06/15/16 DATE.
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS	JGP DRAWN.	SLT CHECKED.	REV. 0 REVISION.

TWOONETWO ENVIRONMENTAL
816 Delta Avenue
Cincinnati, Ohio 45226
(513) 430-1766



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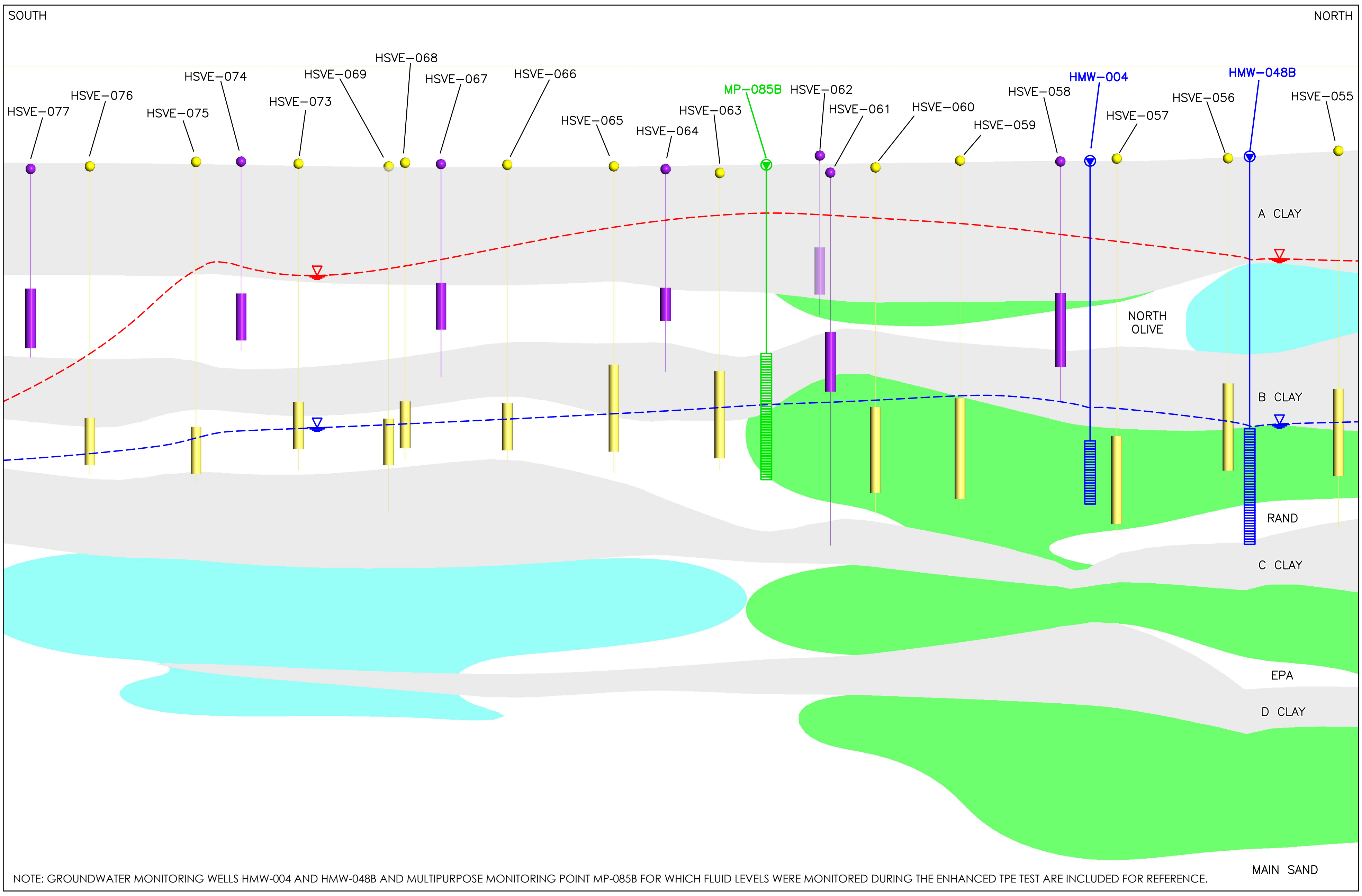
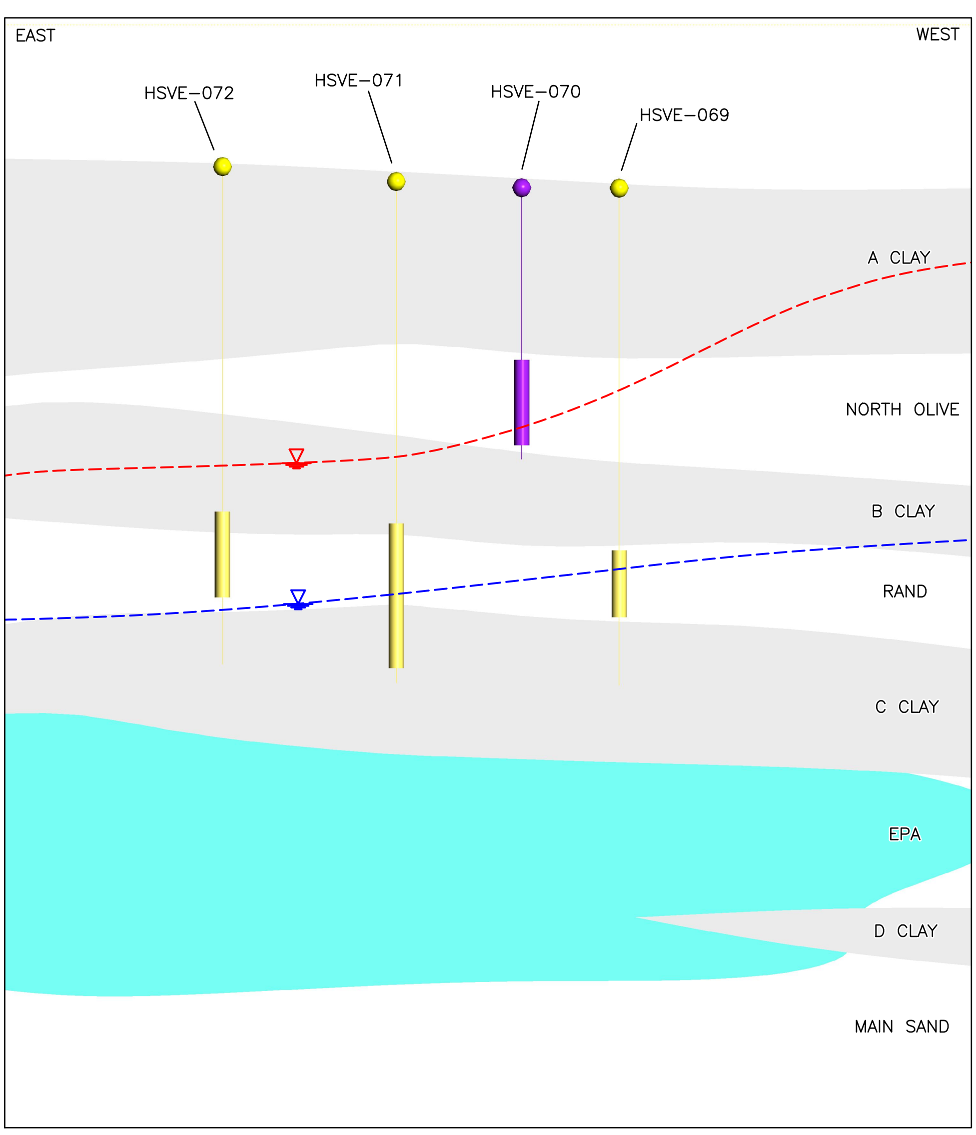
TITLE: FIGURE 4. LINES OF SECTION	1" = 120' SCALE.	16-001-07 PROJECT NO.	08/24/16 DATE.
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS	JGP DRAWN.	SLT CHECKED.	REV. 1 REVISION.

TWO ONE TWO ENVIRONMENTAL
816 Delta Avenue
Cincinnati, Ohio 45226
(513) 430-1766

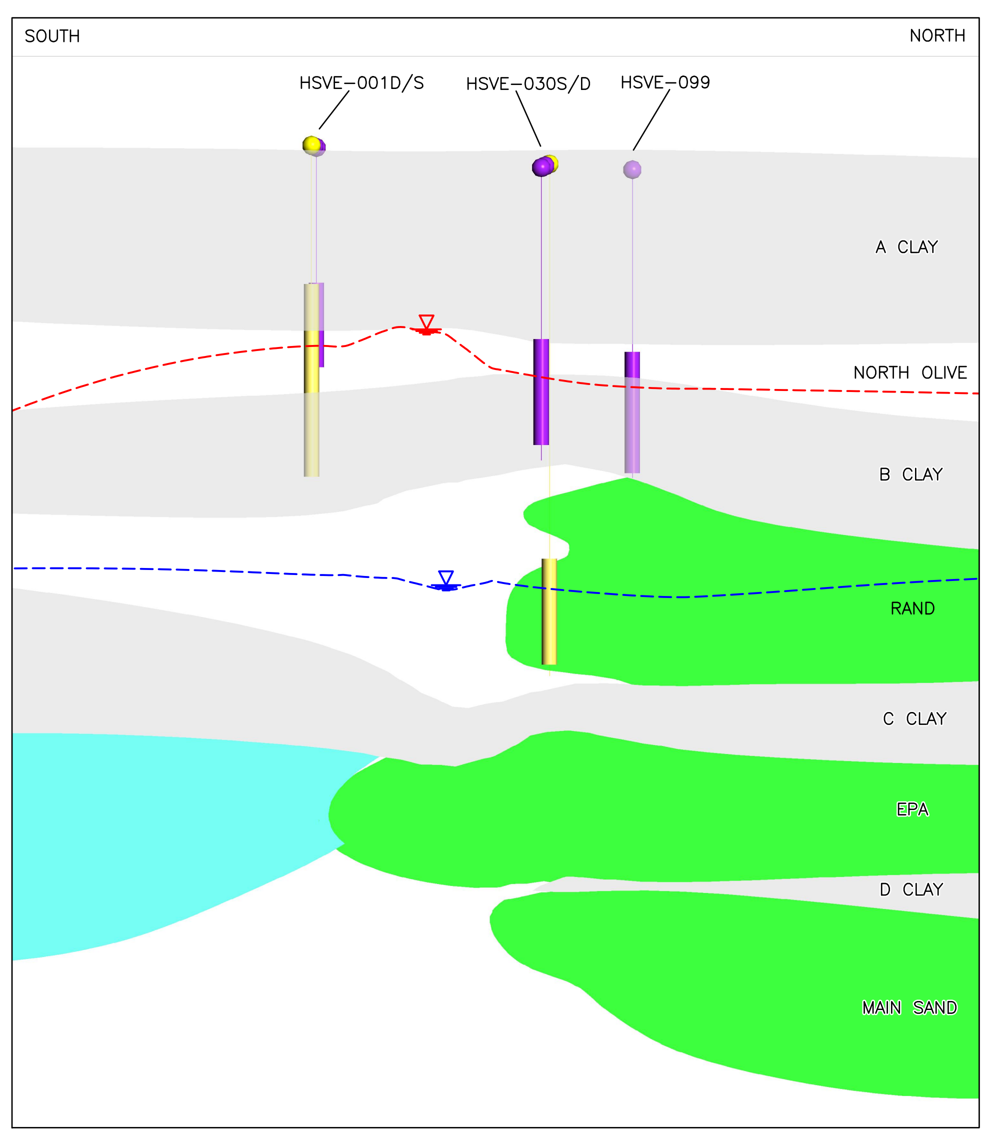
FILE: 00107_05_XSections_201608.dwg



A **SECTION A-A' - NORTH OLIVE AVENUE**
10X VERTICAL EXAGGERATION



B **SECTION B-B' - EAST CHERRY STREET**
10X VERTICAL EXAGGERATION



C **SECTION C-C' - ALLEY**
10X VERTICAL EXAGGERATION

EXPLANATION

- PERCHED GROUNDWATER POTENTIOMETRIC SURFACE (JANUARY 2016)
- PERCHED GROUNDWATER POTENTIOMETRIC SURFACE (SEPTEMBER 2012)
- SHALLOW SVE WELL SCREEN
- DEEP SVE WELL SCREEN
- LIGHT-RANGE LNAPL
- MID-RANGE LNAPL
- HEAVY-RANGE LNAPL
- HMW-004 GROUNDWATER MONITORING WELL
- MP-085B MULTIPURPOSE MONITORING POINT

NOTE: PERCHED GROUNDWATER IS HIGHLY DISCONTINUOUS AND FLOW DIRECTIONS ARE HIGHLY VARIABLE WITHIN THE SHALLOW PERMEABLE STRATA (E.G., NORTH OLIVE AND RAND). FLOW DIRECTION SHOULD NOT BE INFERRED FROM THESE LINES OF SECTION.

TITLE: FIGURE 5. EFFECTIVENESS ZONE 6 EXTRACTION WELL DETAILS	1" = 100' SCALE.	16-001-07 PROJECT NO.	08/24/16 DATE.
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS	JGP DRAWN.	SLT CHECKED.	REV. 0 REVISION.

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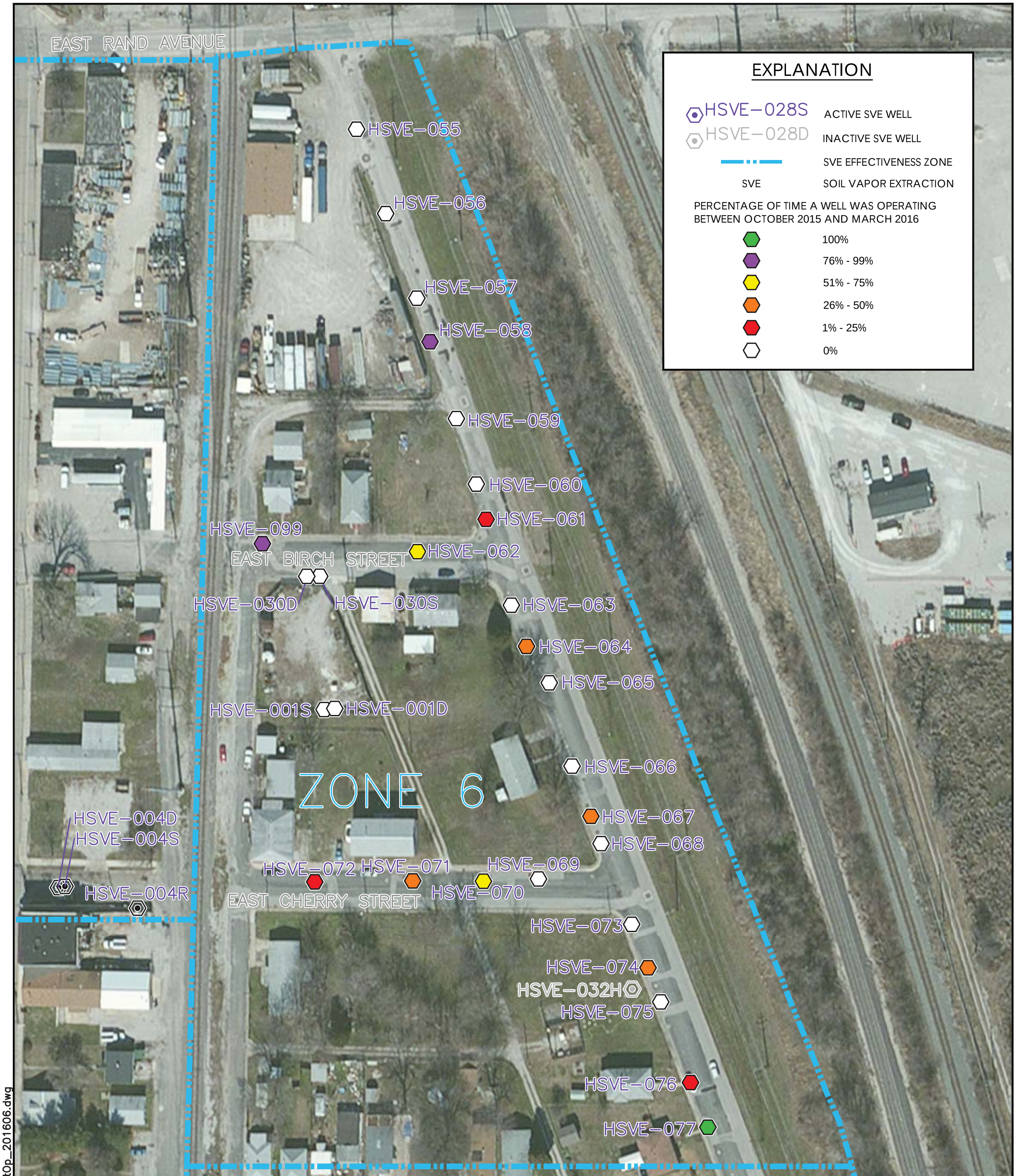
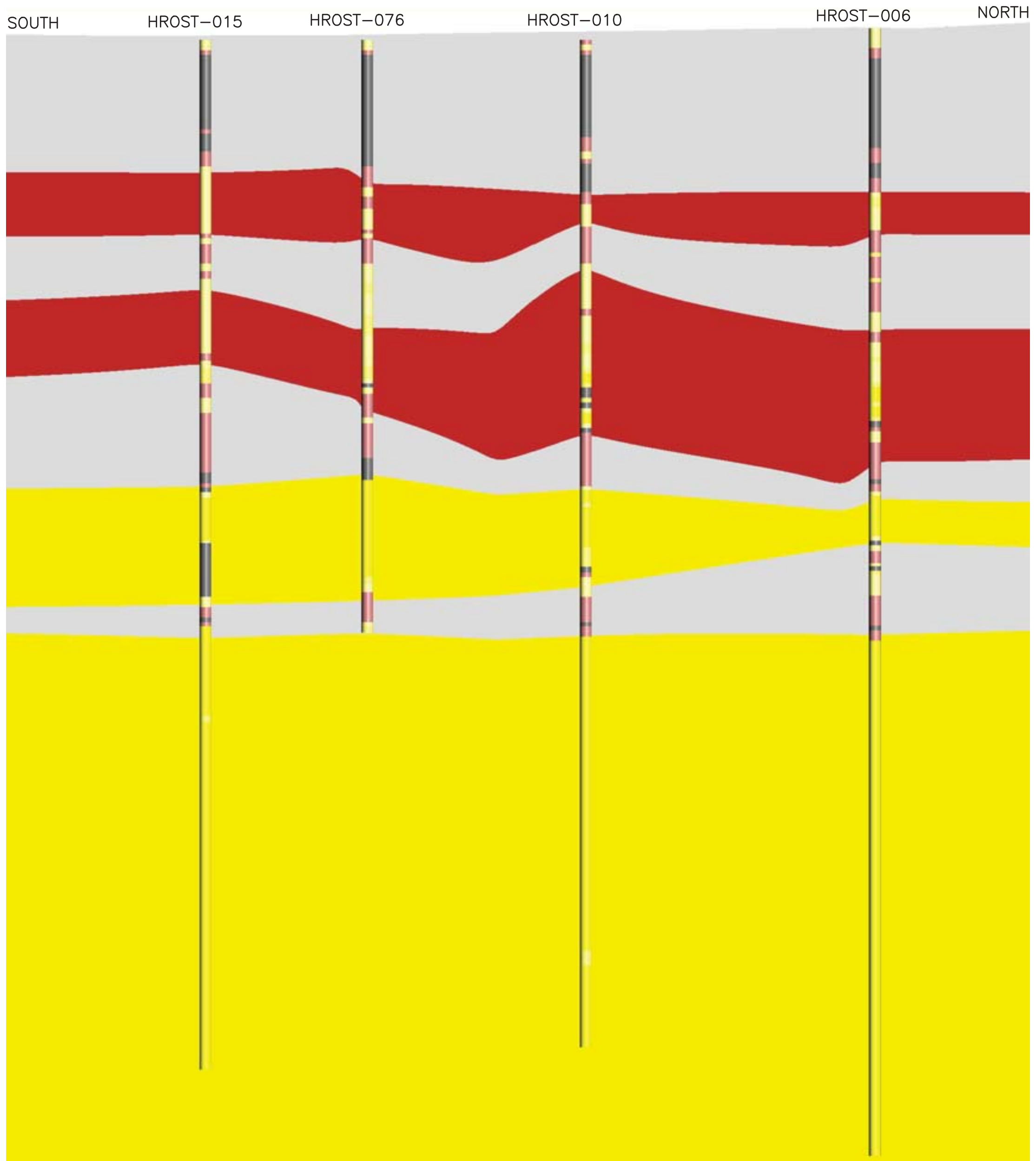


TITLE: FIGURE 6. SUMMARY OF SVE WELL PERCENT OPERATION OCTOBER 2015 AND MARCH 2016	1" = 120' SCALE.	16-001-07 PROJECT NO.	06/16/16 DATE.	TWO ONE TWO ENVIRONMENTAL 816 Delta Avenue Cincinnati, Ohio 45226 (513) 430-1766
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS	JGP DRAWN.	SLT CHECKED.	REV. 0 REVISION.	

FILE: 00107_06_PercentOp_201606.dwg

STRATIGRAPHIC LEGEND

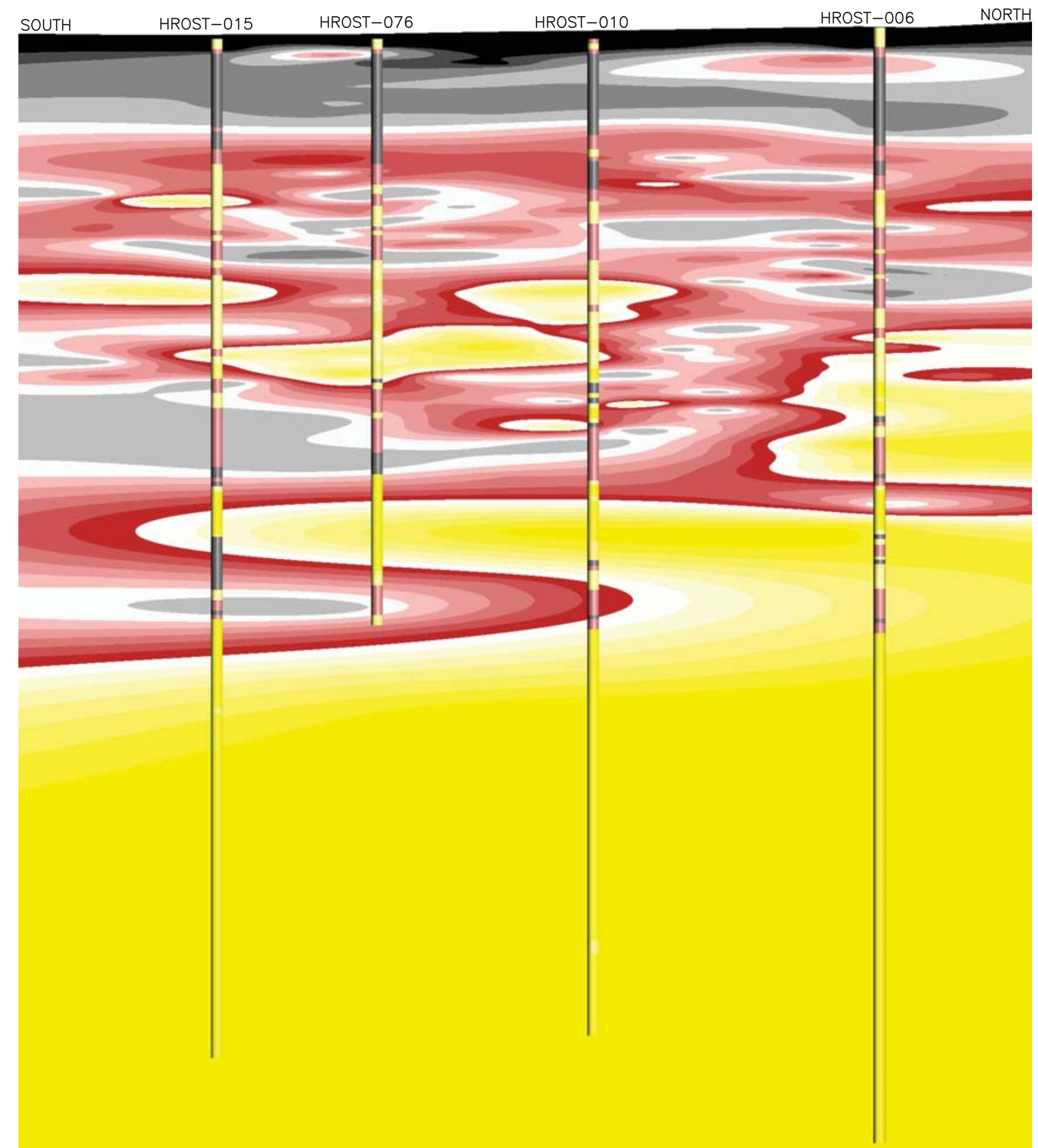
- A Clay
- B Clay
- C Clay
- D Clay
- EPA
- Main Sand
- N. Olive
- Rand



CPT BORING LEGEND

- CL
- ML/CL
- SM/SC
- SM
- SP

Ⓐ GENERALIZED STRATIGRAPHIC INTERPRETATION
10X VERTICAL EXAGGERATION

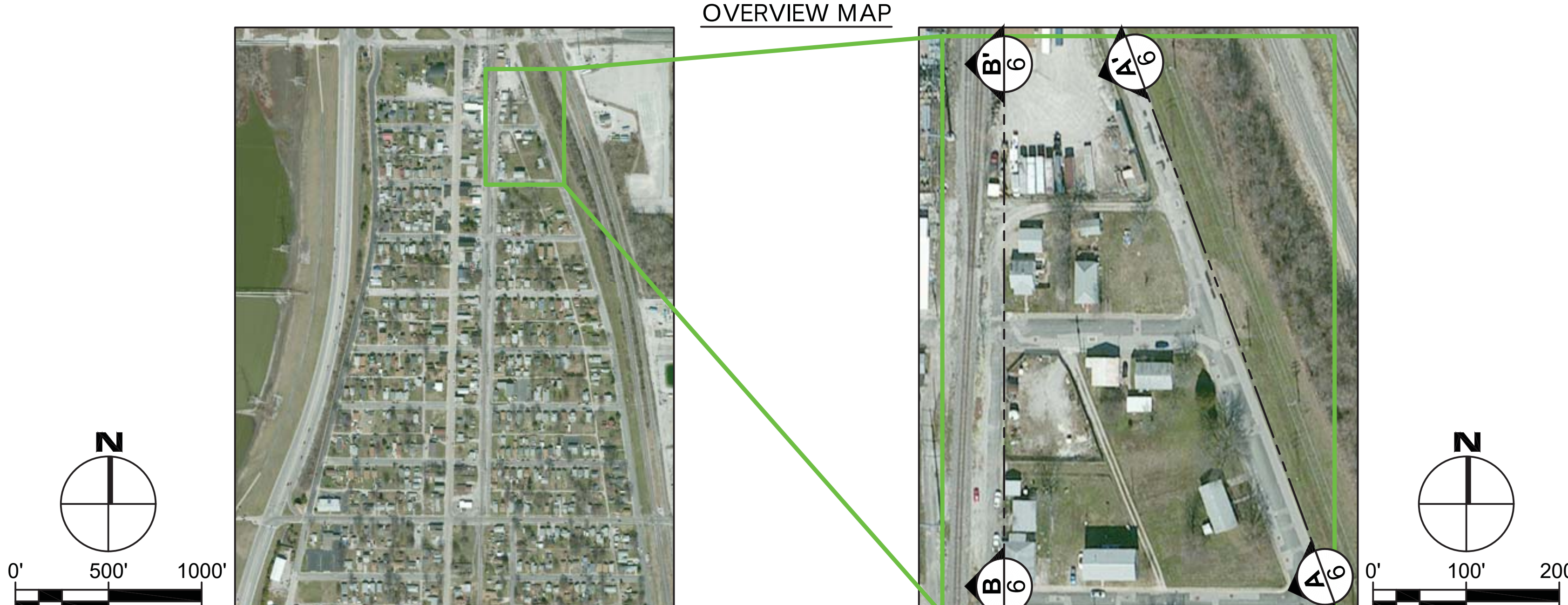


LITHOLOGIC LEGEND

- ASPHALT
- FILL
- CH
- CL
- CL/ML
- MH/CH
- ML/CH
- ML/CL
- ML
- ML/SM
- SM/ML
- SC
- SC/SM
- SM/SC
- SM
- SM/SP
- SP
- SW

Ⓑ DETAILED LITHOLOGIC INTERPRETATION
10X VERTICAL EXAGGERATION

OVERVIEW MAP



EXPLANATION

CPT CONE PENETRATING TEST

TITLE: FIGURE 7. GENERALIZED STRATIGRAPHIC AND DETAILED LITHOLOGIC INTERPRETATIONS ALONG NORTH OLIVE AVENUE

SITE: HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

1" = 120' SCALE.	16-001-07 PROJECT NO.	06/20/16 DATE.
JGP DRAWN.	PEM CHECKED.	REV. 0 REVISION.

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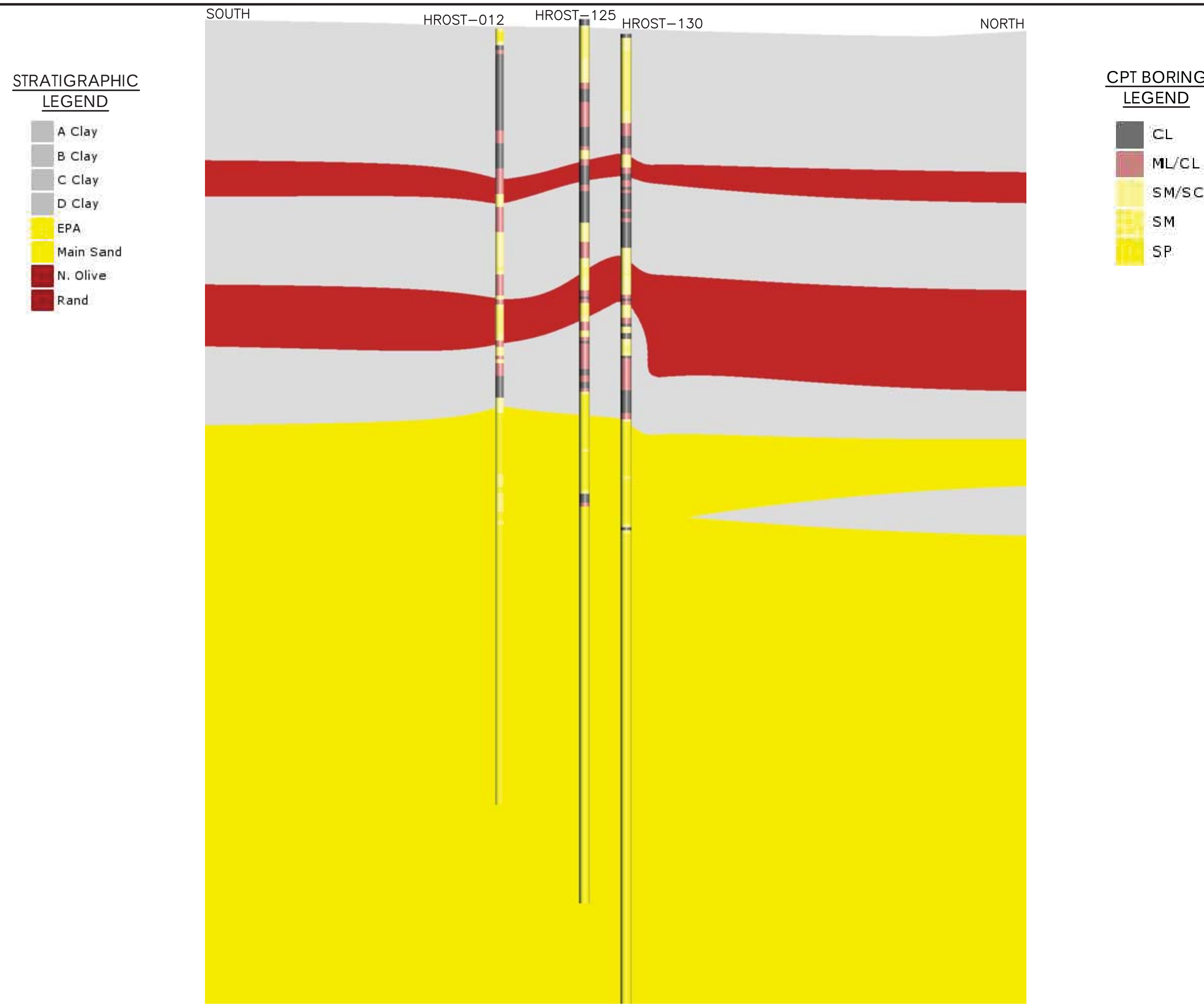
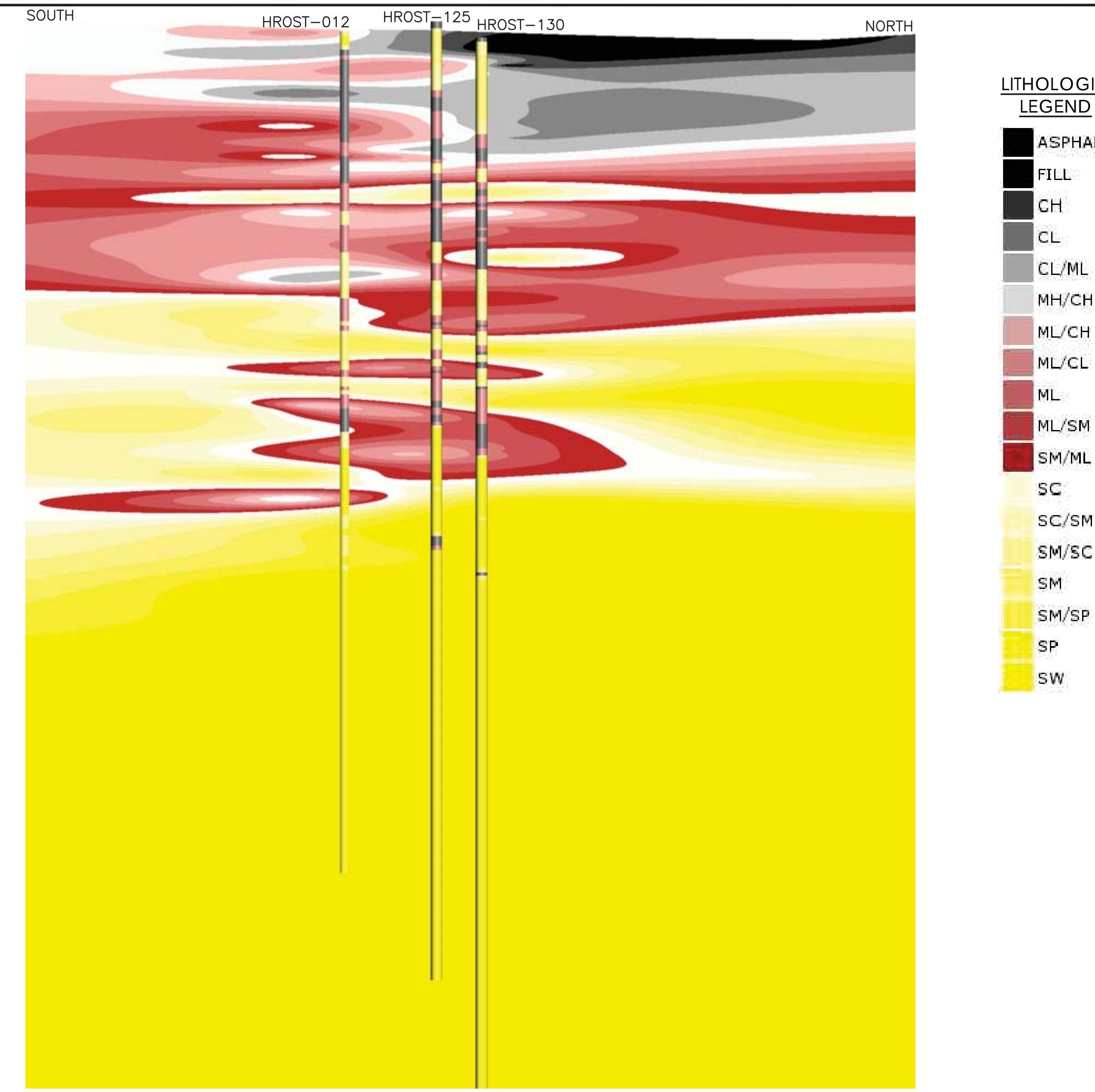
FILE: 00107_07_NorthOliveLithologyCompare_201606.dwg

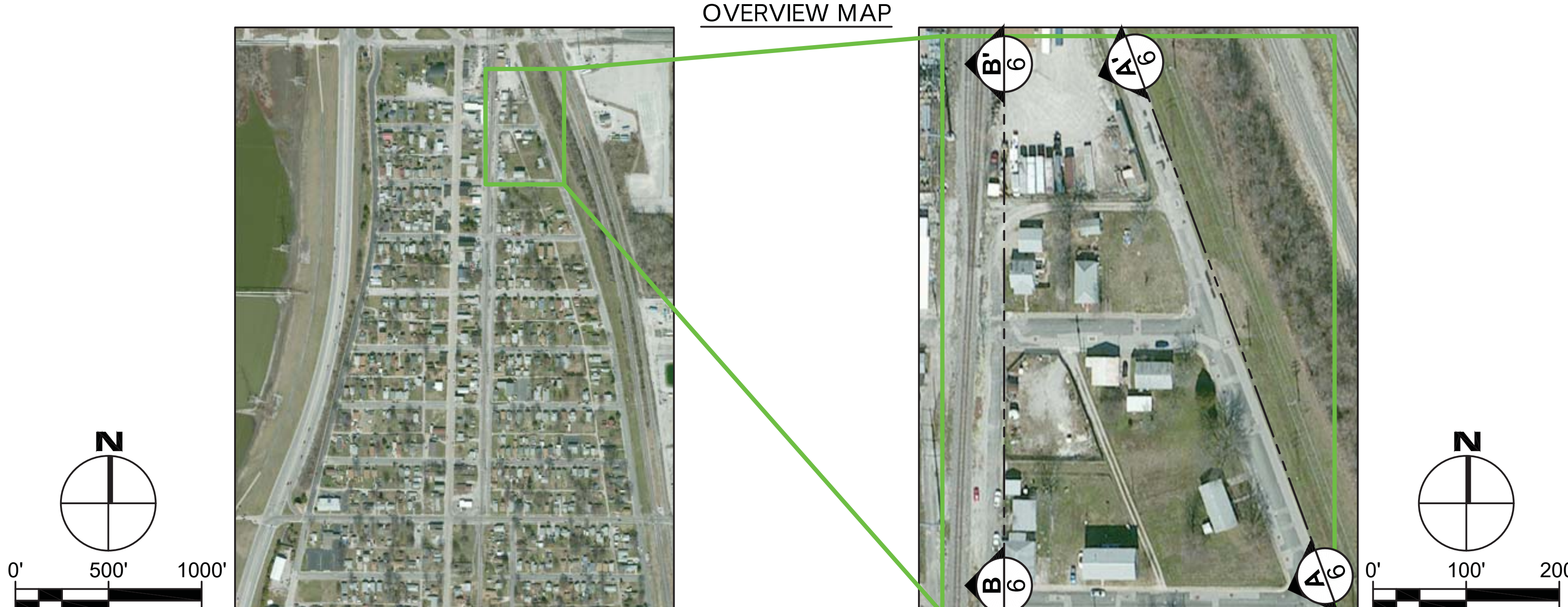


A GENERALIZED STRATIGRAPHIC INTERPRETATION
10X VERTICAL EXAGGERATION



B DETAILED LITHOLOGIC INTERPRETATION
10X VERTICAL EXAGGERATION

OVERVIEW MAP



EXPLANATION

CPT CONE PENETRATING TEST

TITLE: FIGURE 8. GENERALIZED STRATIGRAPHIC AND DETAILED LITHOLOGIC INTERPRETATIONS ALONG NORTH MARKET STREET		
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS		
1" = 120' SCALE.	16-001-07 PROJECT NO.	06/20/16 DATE.
JGP DRAWN.	PEM CHECKED.	REV. 0 REVISION.

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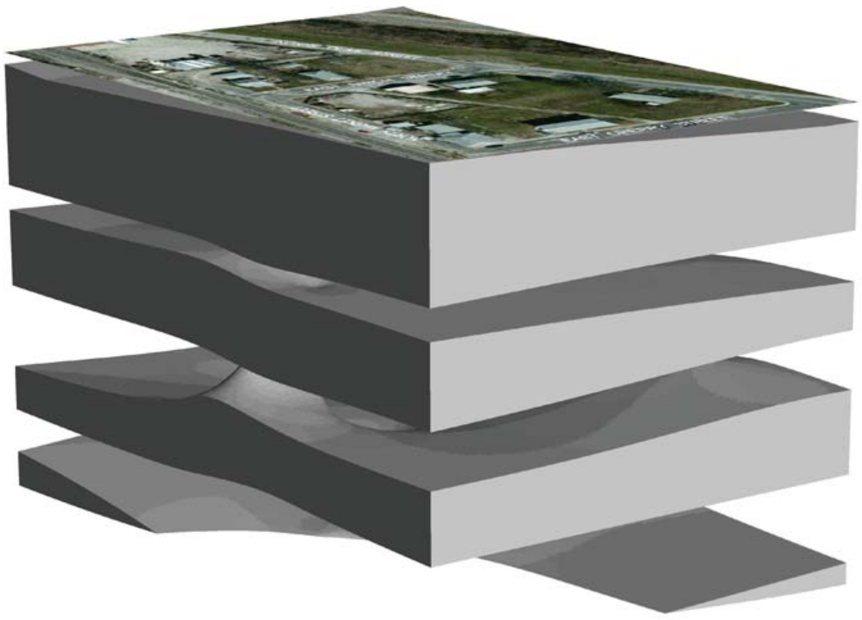
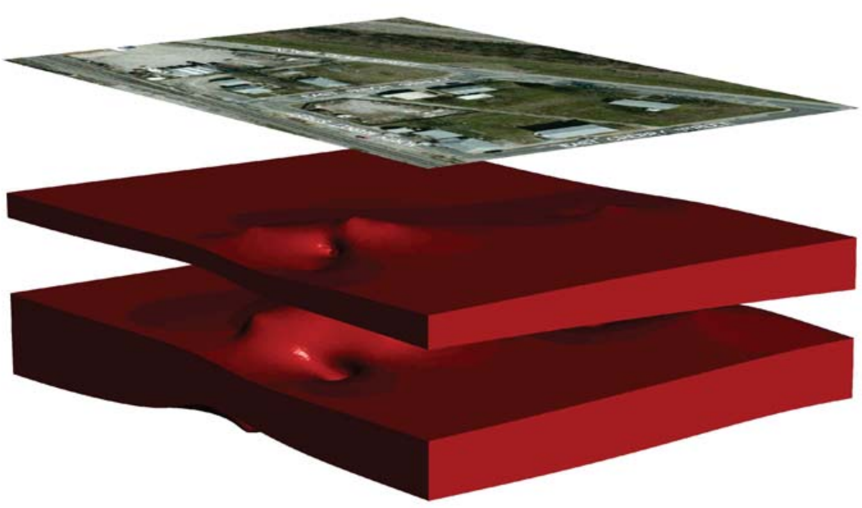
FILE: 00107_08_NorthMarketLithologyCompare_201606.dwg

FILE: 00107_09_IsometricsCompare_201606.dwg

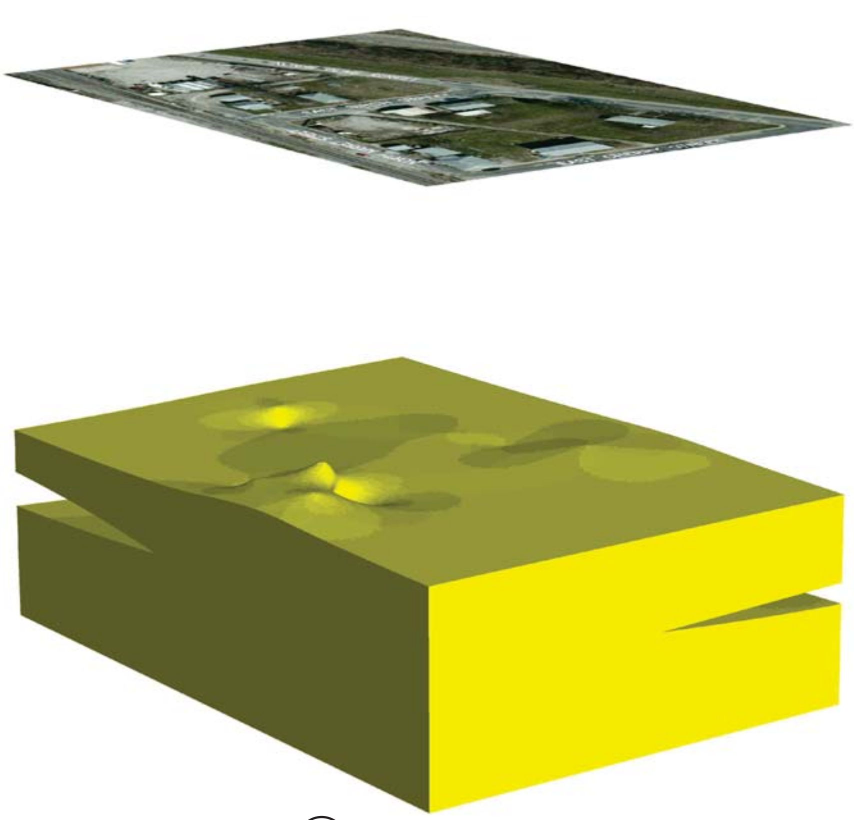
GENERALIZED STRATIGRAPHIC INTERPRETATIONS



(A) **CLAYEY STRATA**
10X VETICAL EXAGGERATION



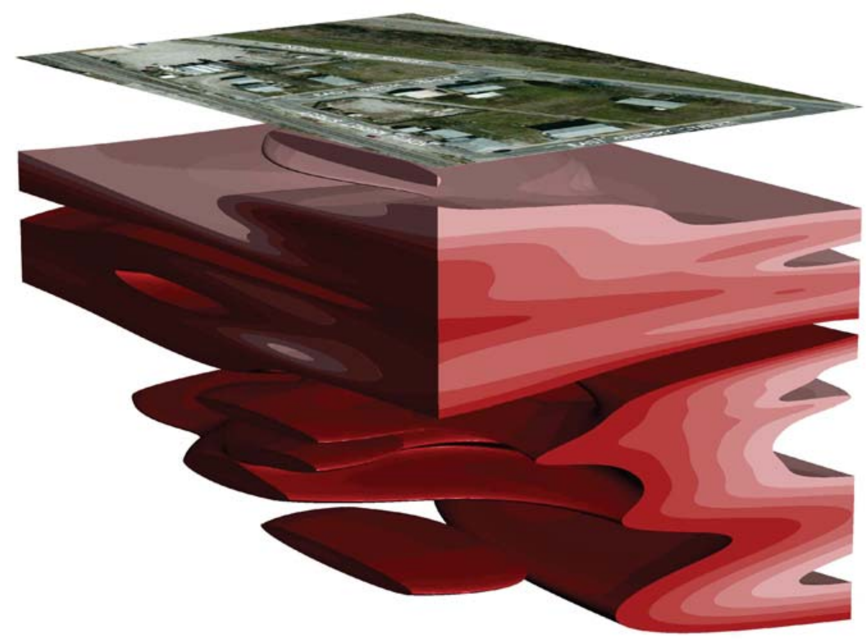
(C) **SILTY STRATA**
10X VETICAL EXAGGERATION



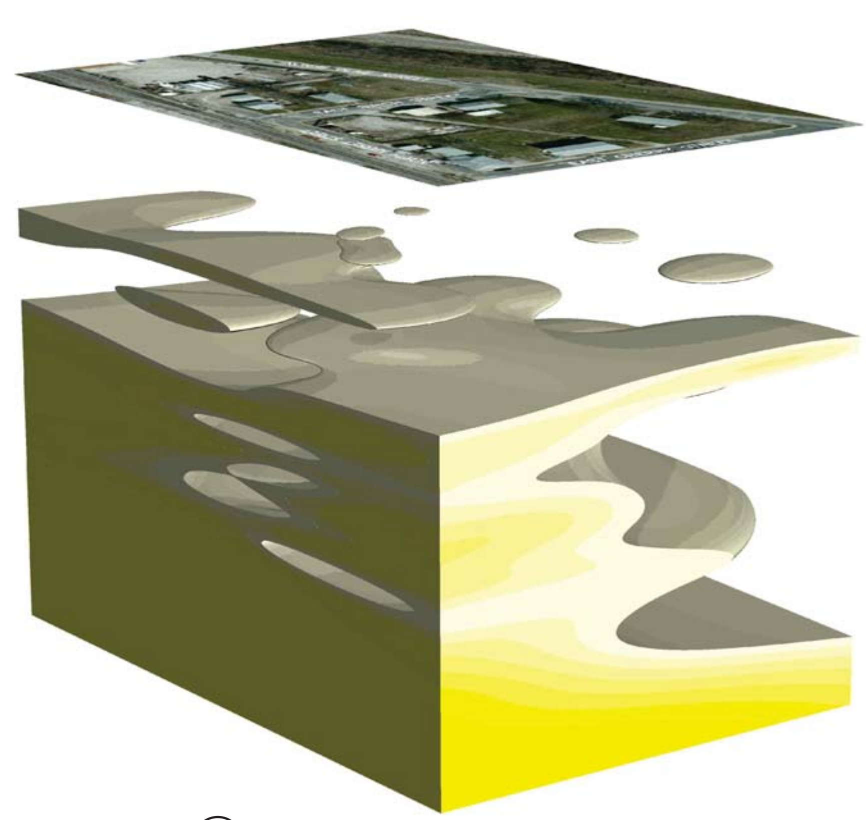
(E) **COARSE-GRAINED STRATA**
10X VETICAL EXAGGERATION

DETAILED LITHOLOGIC INTERPRETATIONS

(B) **CLAYEY SOIL TYPES**
10X VETICAL EXAGGERATION



(D) **SILTY SOILS TYPES**
10X VETICAL EXAGGERATION



(F) **COARSE-GRAINED SOIL TYPES**
10X VETICAL EXAGGERATION

STRATIGRAPHIC LEGEND

- A Clay
- B Clay
- C Clay
- D Clay
- EPA
- Main Sand
- N. Olive
- Rand

LITHOLOGIC LEGEND

- ASPHALT
- FILL
- CH
- CL
- CL/ML
- MH/CH
- ML/CH
- ML/CL
- ML
- ML/SM
- SM/ML
- SC
- SC/SM
- SM/SC
- SM
- SM/SP
- SP
- SW

TITLE: FIGURE 9. 3D VISUALIZATIONS OF GENERALIZED STRATIGRAPHIC AND DETAILED LITHOLOGIC INTERPRETATIONS	NO SCALE SCALE.	16-001-07 PROJECT NO.	06/20/16 DATE.
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS	JGP DRAWN.	PEM CHECKED.	REV. 0 REVISION.

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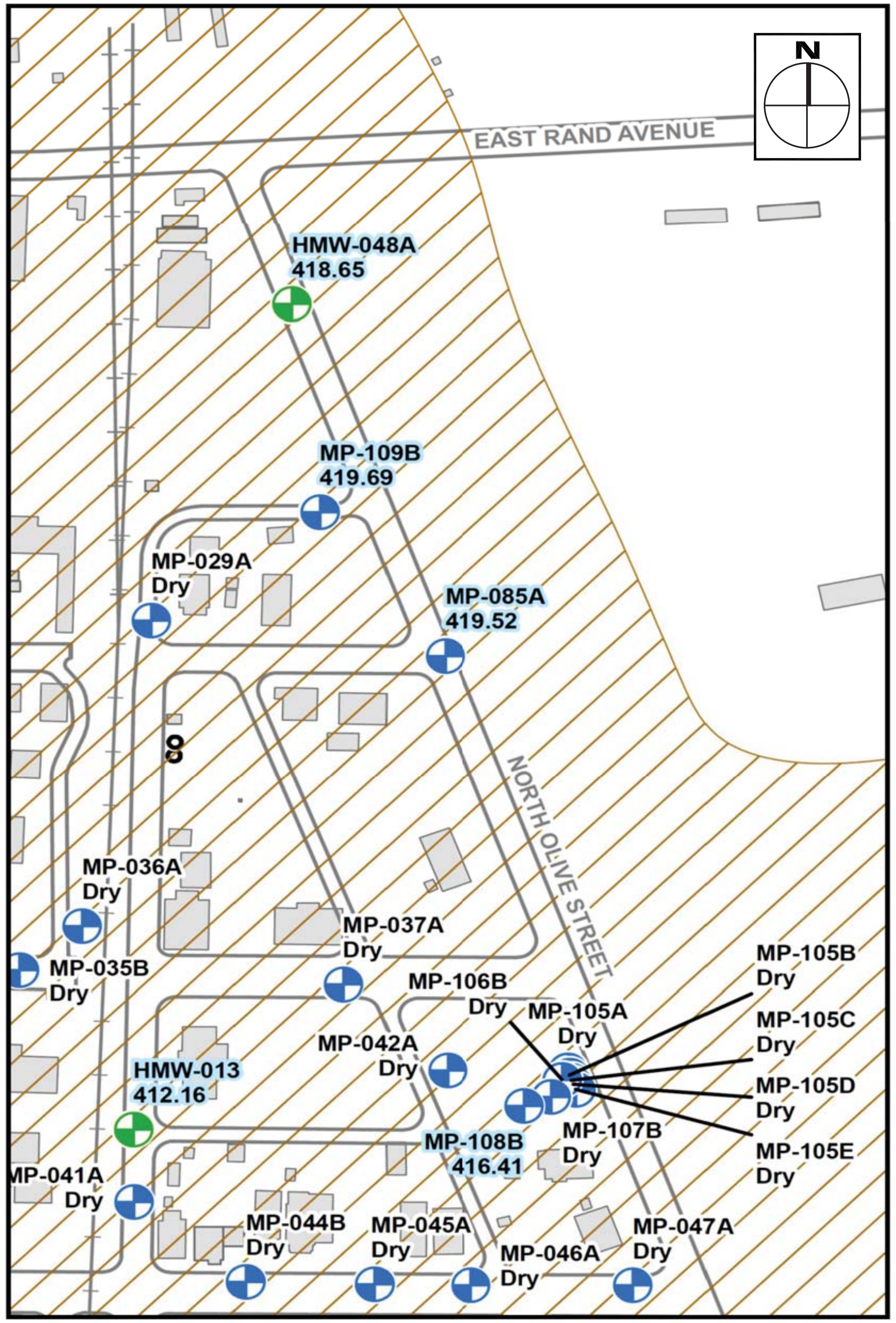
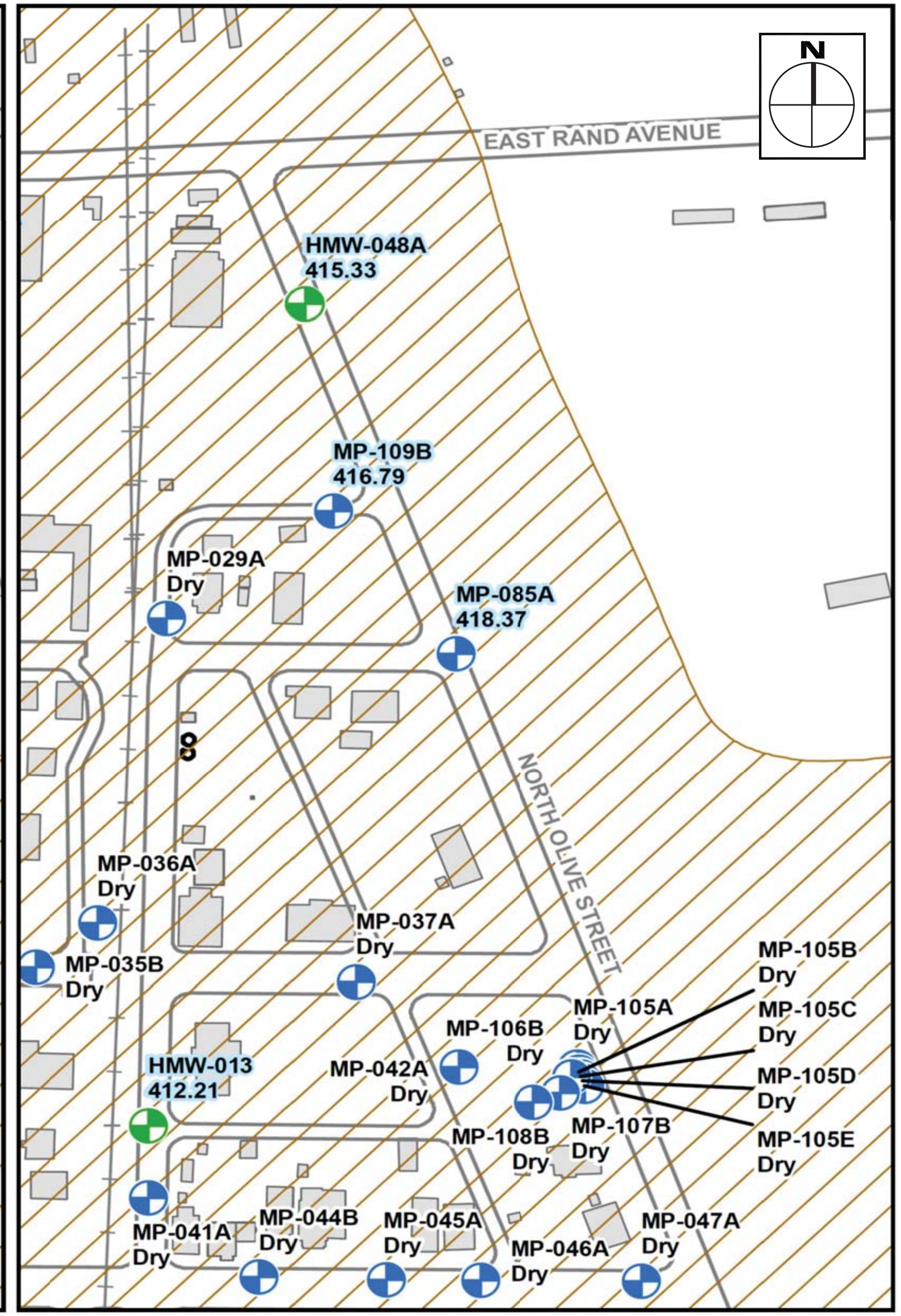
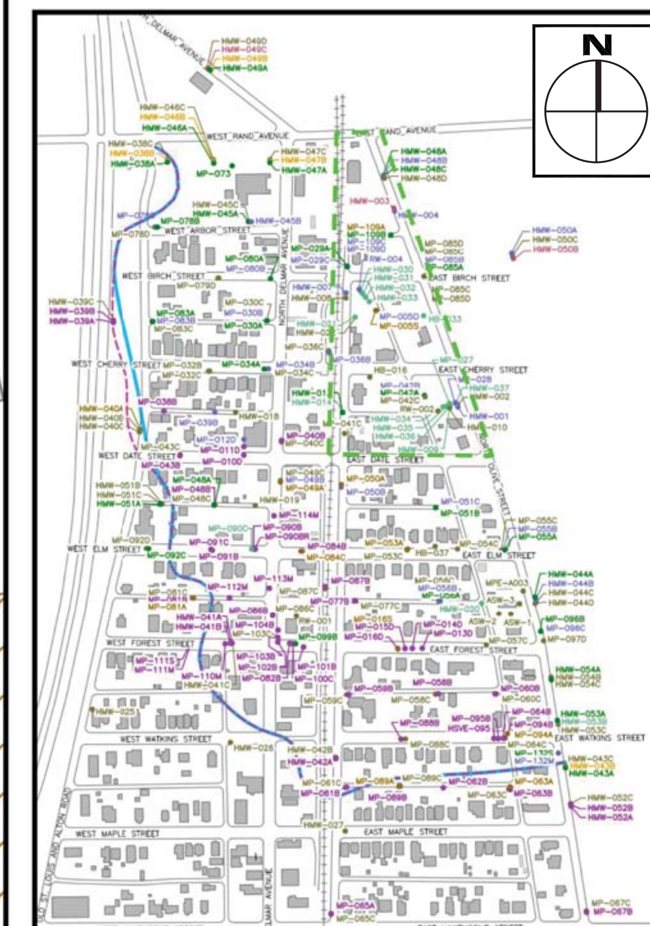


(A) SECOND QUARTER 2014
HIGH WATER TABLE



(B) FOURTH QUARTER 2013
LOW WATER TABLE



(B) OVERVIEW MAP

TITLE: FIGURE 10. GROUNDWATER ELEVATIONS NORTH OLIVE STRATUM		
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS		
VARIABLE SCALE.	16-001-07 PROJECT NO.	06/20/16 DATE.
JGP DRAWN.	TAA CHECKED.	REV. 0 REVISION.

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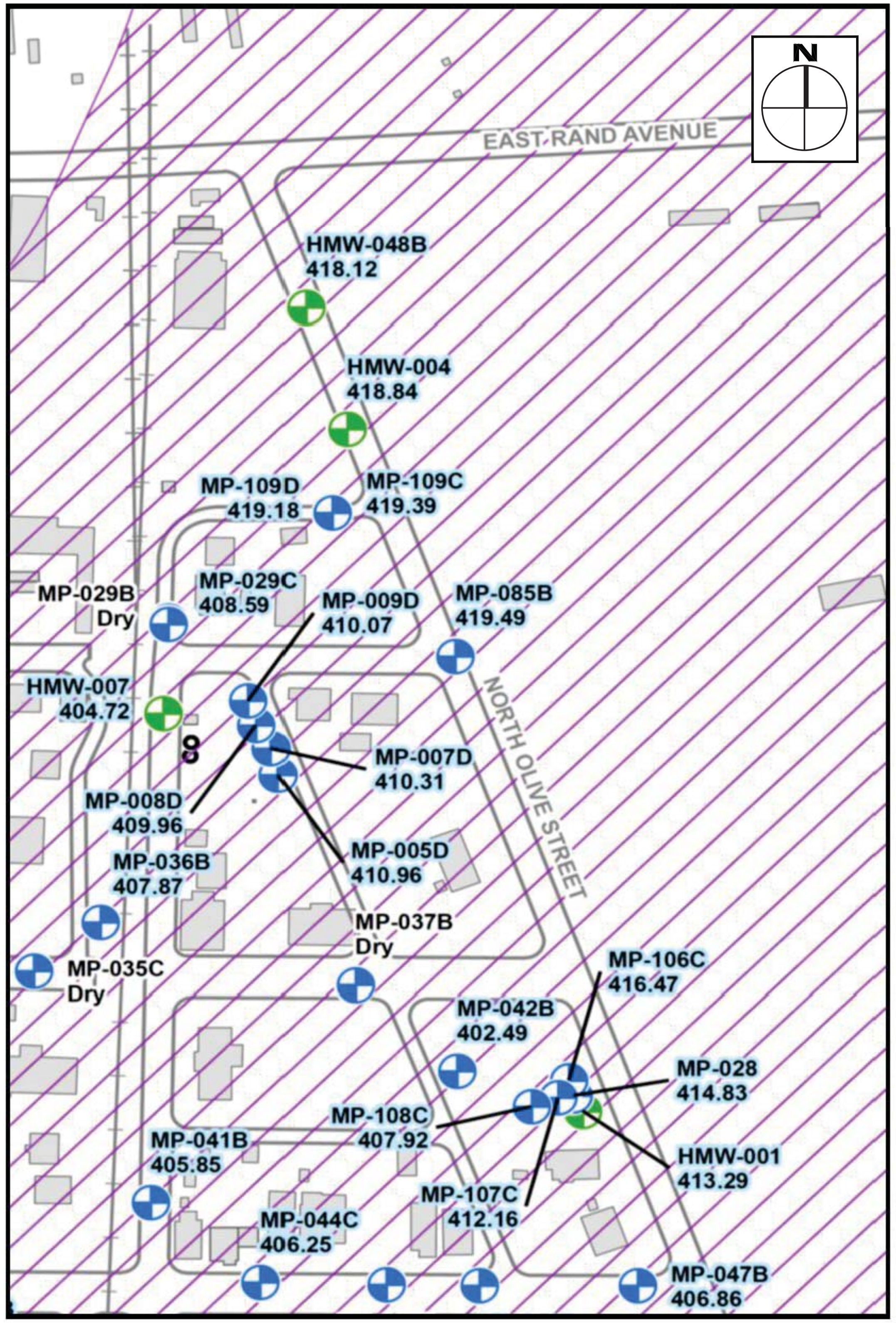
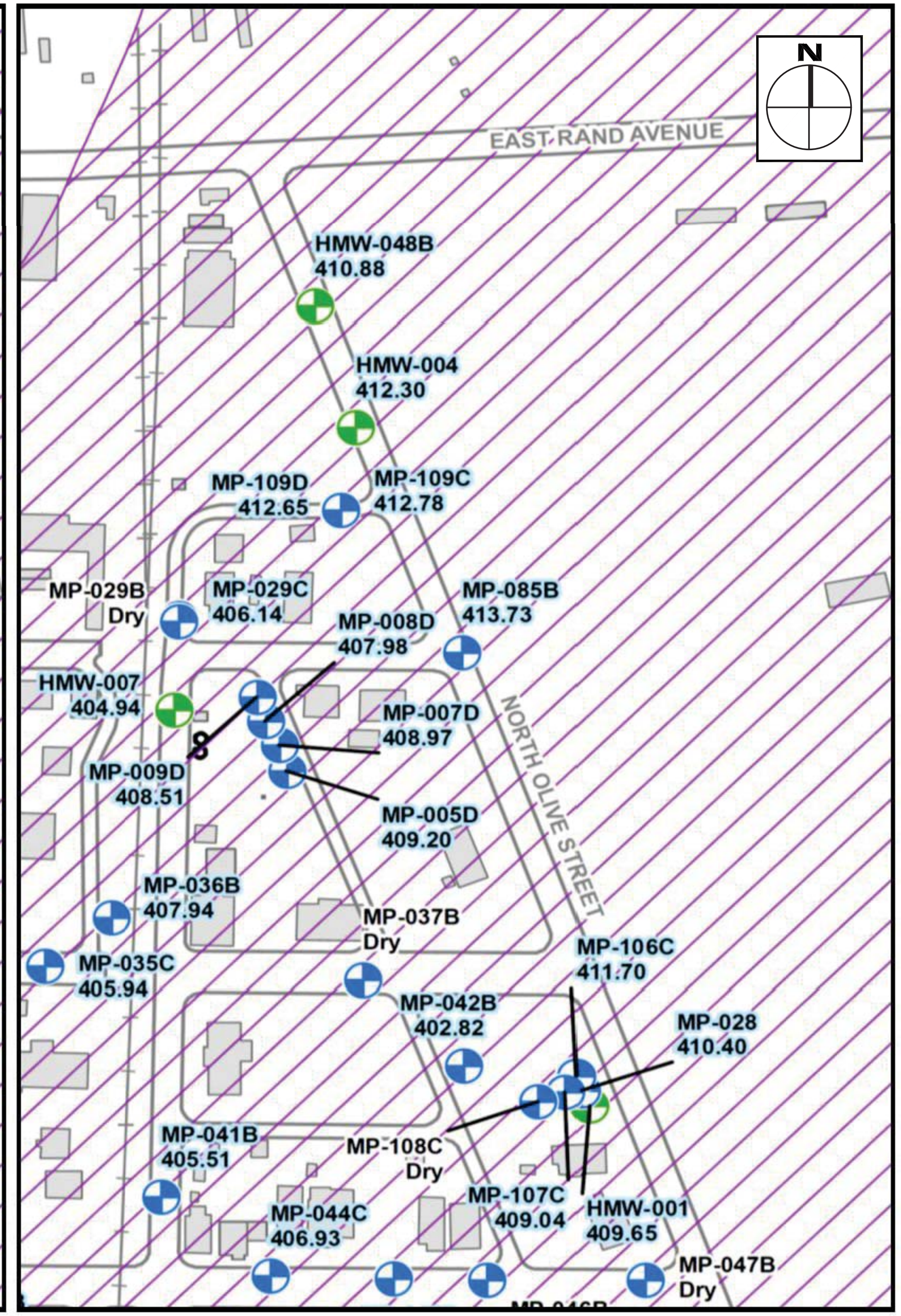
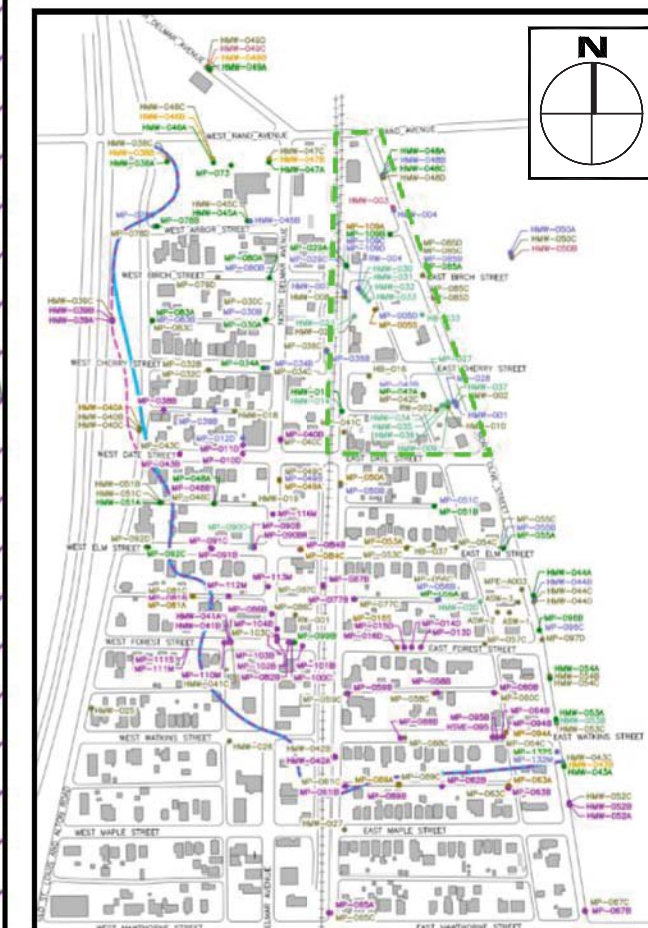
FILE: 00107_12-14__GW_Elevations_201606.dwg



A SECOND QUARTER 2014
HIGH WATER TABLE



B FOURTH QUARTER 2013
LOW WATER TABLE



B OVERVIEW MAP

TITLE: FIGURE 11. GROUNDWATER ELEVATIONS RAND STRATUM		
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS		
VARIABLE SCALE.	16-001-07 PROJECT NO.	06/20/16 DATE.
JGP DRAWN.	TAA CHECKED.	REV. 0 REVISION.

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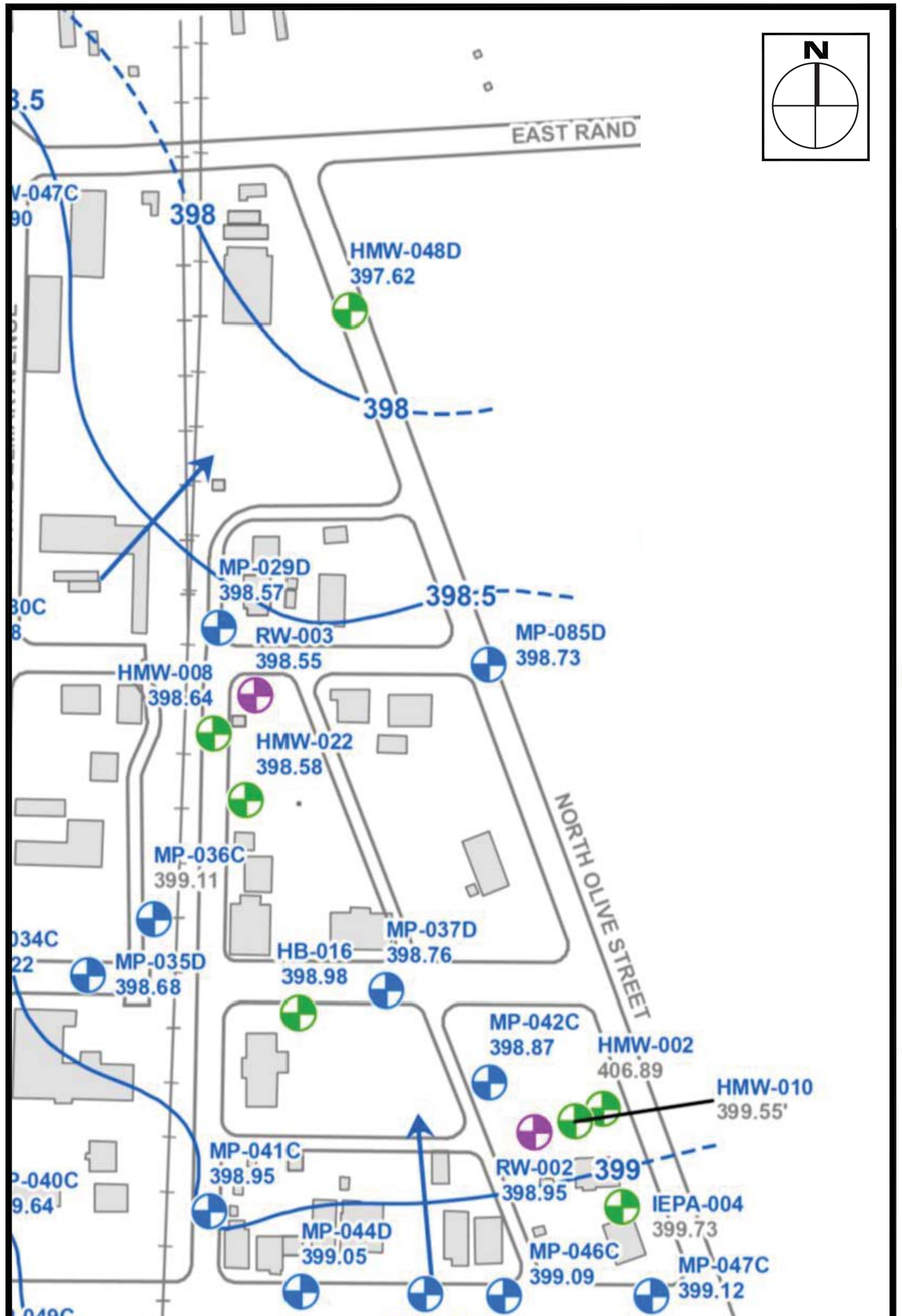
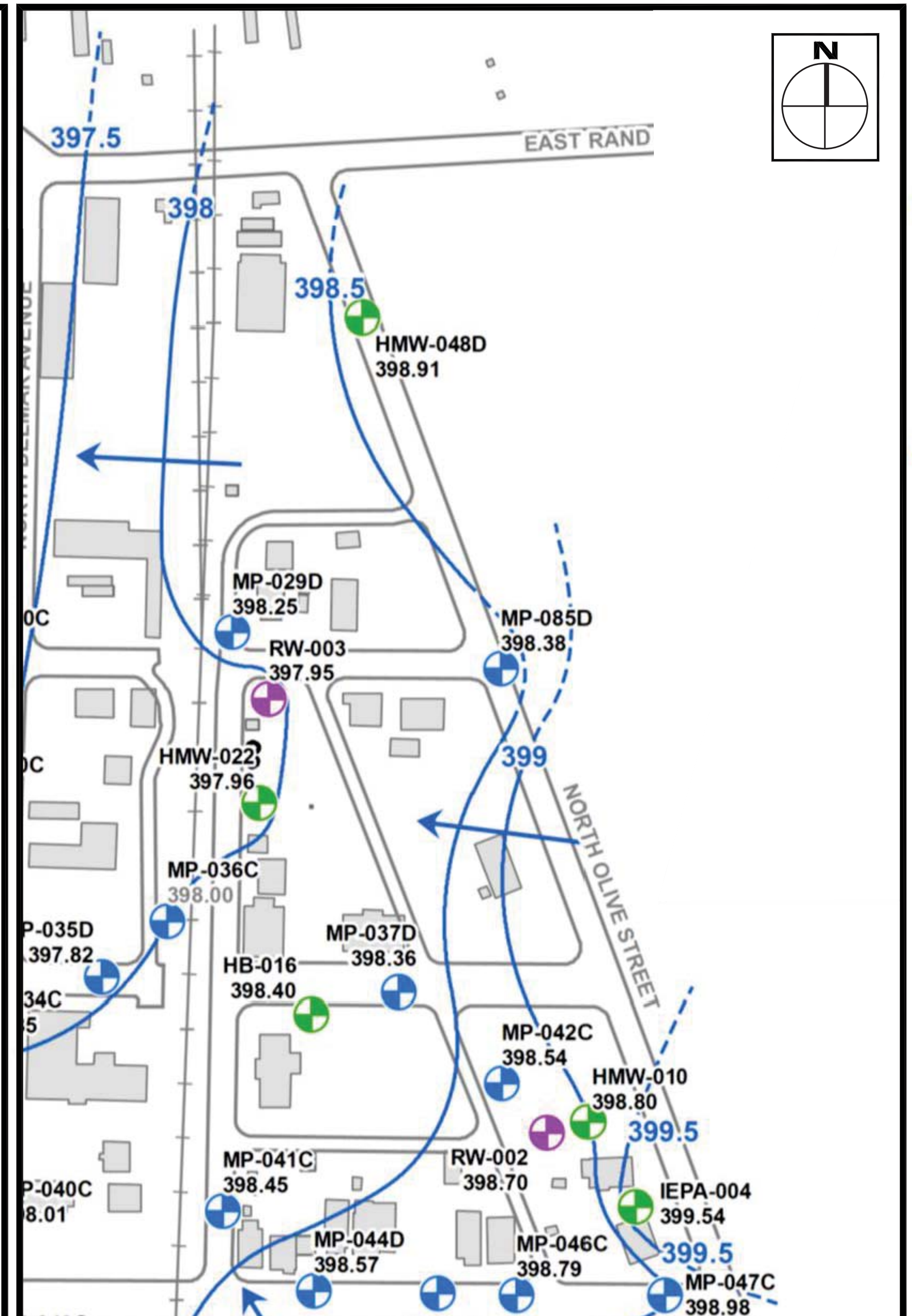
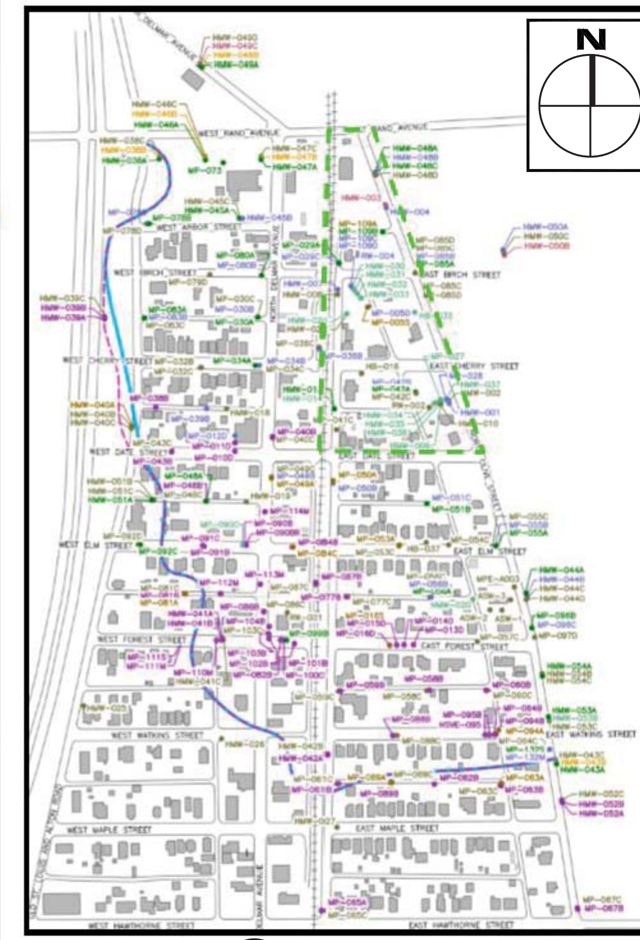
FILE: 00107_12-14__GW_Elevations_201606.dwg



A SECOND QUARTER 2014
HIGH WATER TABLE



B FOURTH QUARTER 2013
LOW WATER TABLE



B OVERVIEW MAP

TITLE: FIGURE 12. POTENTIOMETRIC SURFACE MAP MAIN SAND STRATUM		
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS		
VARIABLE SCALE.	16-001-07 PROJECT NO.	06/20/16 DATE.
JGP DRAWN.	TAA CHECKED.	REV. 0 REVISION.

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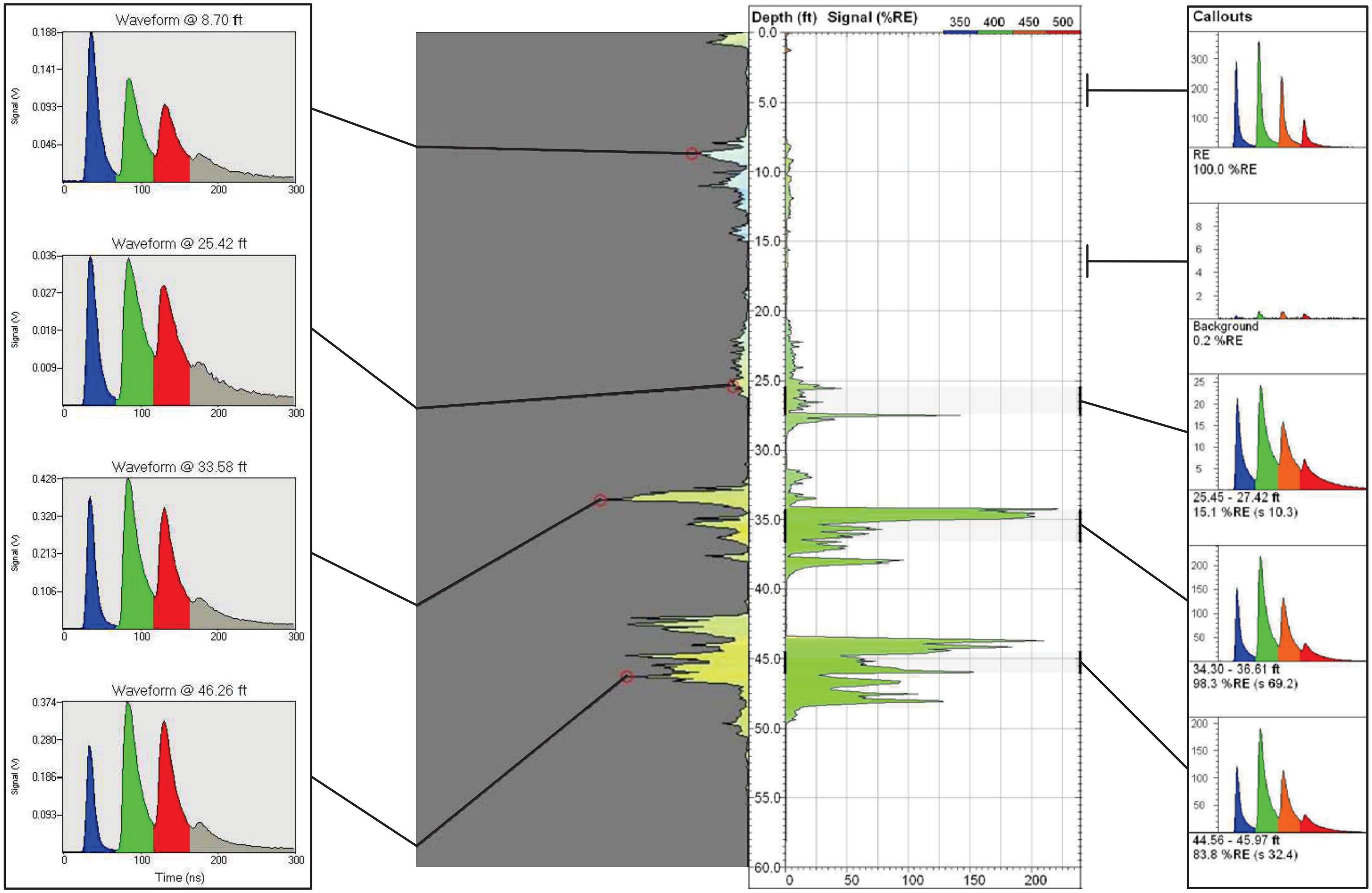
FILE: 00107_12-14__GW_Elevations_201606.dwg

FILE: 00107_10_HUVOST-004_201606.dwg



A HROST-004, FEBRUARY 2004
MIRRORED AND SCALED TO B

B HUVOST-004, SEPTEMBER 2013
SCALE AS SHOWN

NOTE:
THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

TITLE: FIGURE 13. FLUORESCENCE RESPONSE COMPARISON FOR HUVOST-004 LOCATION	NO SCALE SCALE.	16-001-07 PROJECT NO.	06/20/16 DATE.
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS	JGP DRAWN.	PEM CHECKED.	REV. 0 REVISION.

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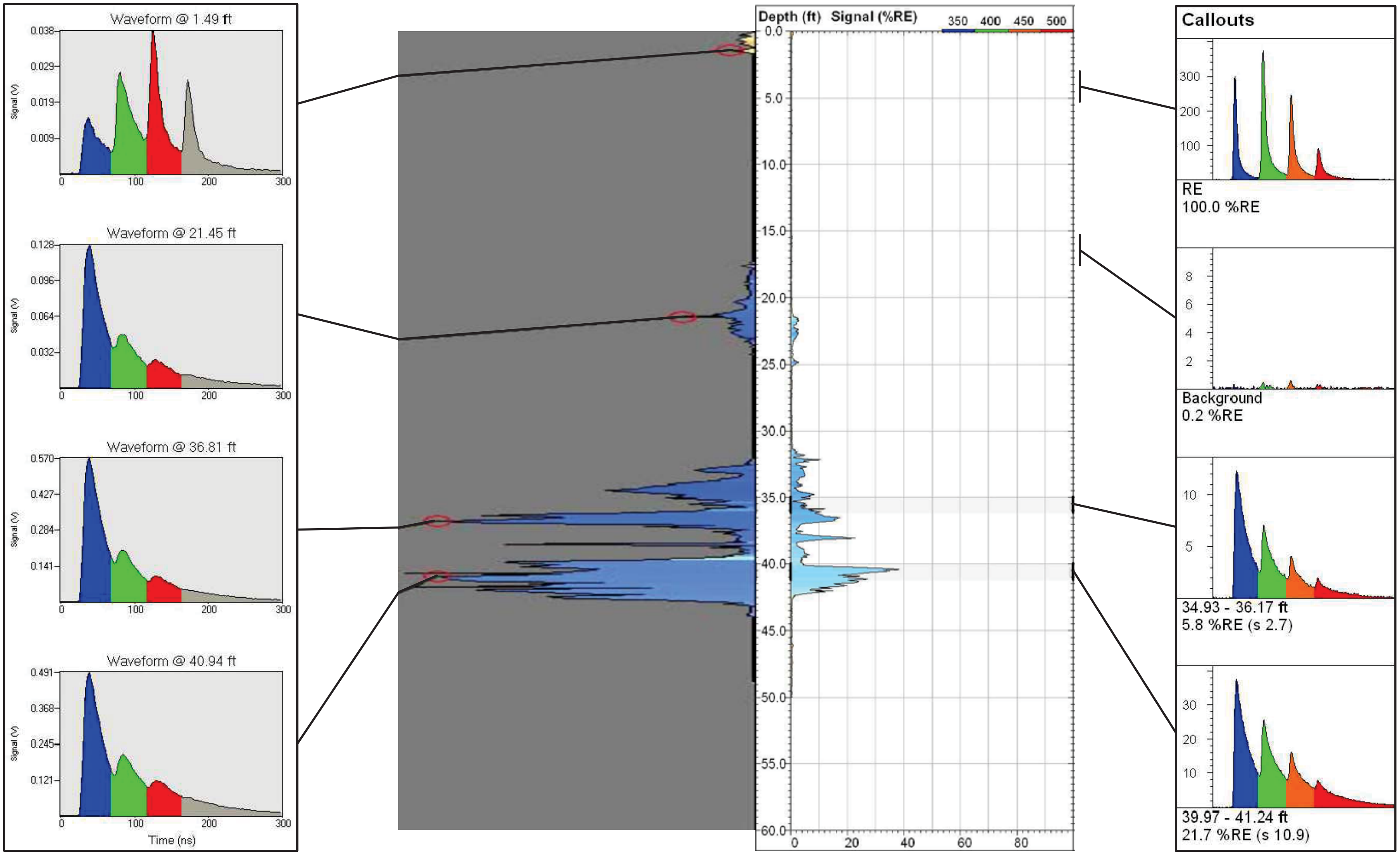
FILE: 00107_11_HUVOST-030_201606.dwg



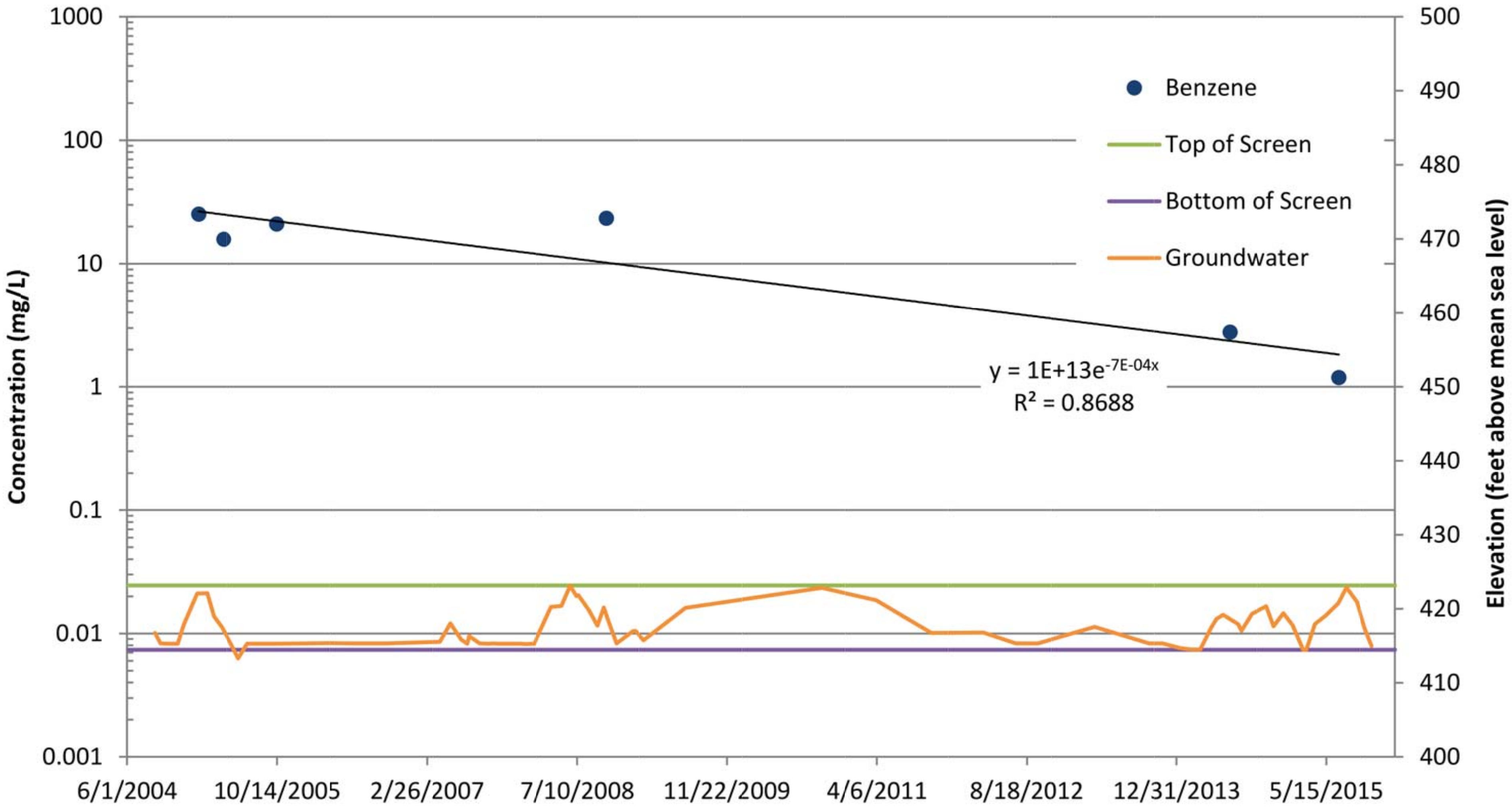
A **HROST-004, FEBRUARY 2004**
MIRRORED AND SCALED TO B

B **HUVOST-004, SEPTEMBER 2013**
SCALE AS SHOWN

NOTE:
THE PERCENT FLUORESCENCE RESPONSE (%RE) CANNOT BE QUANTITATIVELY CORRELATED TO PETROLEUM-RELATED CONSTITUENT CONCENTRATIONS OR HYDROCARBON SATURATIONS AND MAY VARY DEPENDING UPON THE CALIBRATION PERFORMED PRIOR TO ADVANCING A BORING AS WELL AS OTHER FACTORS. WHILE THE %RE AT THE LEFT WAS SCALED TO THAT ON THE RIGHT, THIS ONLY PROVIDES FOR A SEMI-QUANTITATVE COMPARISON OF THE LASER INDUCED FLUORESCENCE.

TITLE: FIGURE 14. FLUORESCENCE RESPONSE COMPARISON FOR HUVOST-030 LOCATION	NO SCALE SCALE.	16-001-07 PROJECT NO.	06/20/16 DATE.	TWOONETWO ENVIRONMENTAL 816 Delta Avenue Cincinnati, Ohio 45226 (513) 430-1766
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS	JGP DRAWN.	PEM CHECKED.	REV. 0 REVISION.	

FILE: 00107_15-17_BenzeneAnalyses_201606.dwg



TITLE: FIGURE 15. DISSOLVED PHASE BENZENE CONCENTRATION TREND FOR MONITORING WELL HMW-048A - NORTH OLIVE STRATUM	NO SCALE SCALE.	16-001-07 PROJECT NO.	06/20/16 DATE.
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS	JGP DRAWN.	PEM CHECKED.	REV. 0 REVISION.

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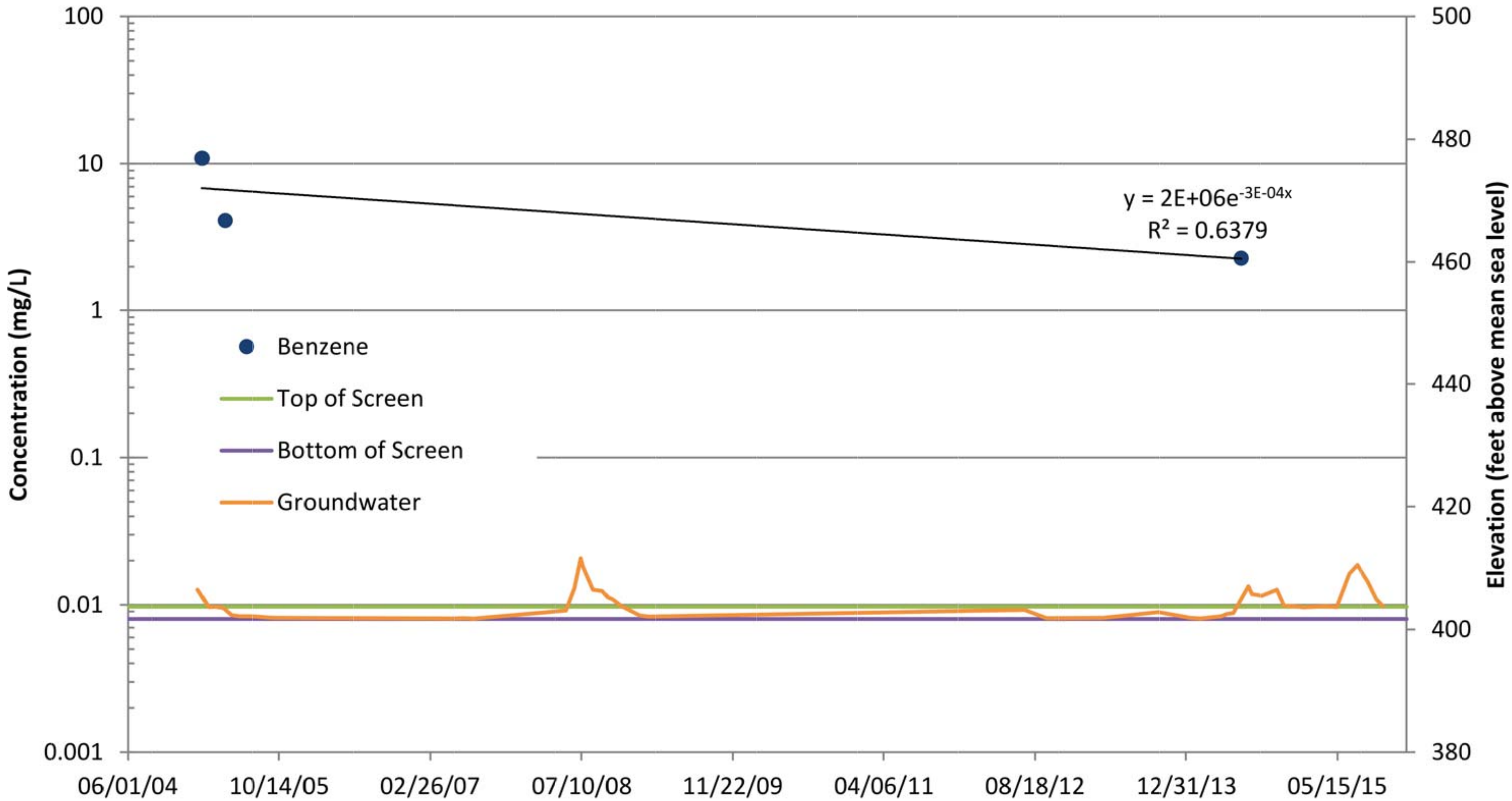
FILE: 00107_15-17_BenzeneAnalyses_201606.dwg



TITLE: FIGURE 16. DISSOLVED PHASE BENZENE CONCENTRATION TREND FOR MONITORING WELL MP-042B - RAND STRATUM	NO SCALE SCALE.	16-001-07 PROJECT NO.	06/20/16 DATE.
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS	JGP DRAWN.	PEM CHECKED.	REV. 0 REVISION.

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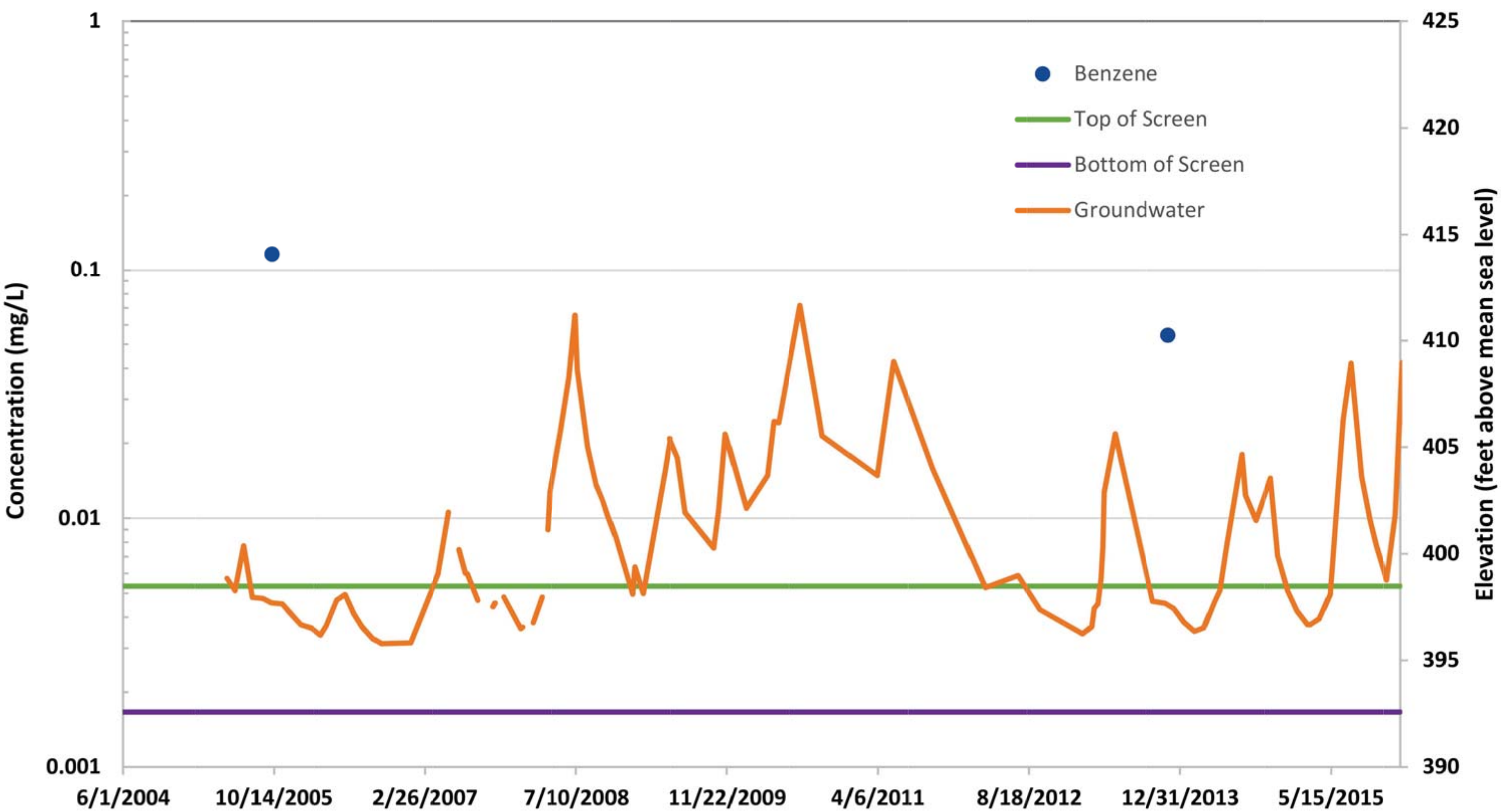
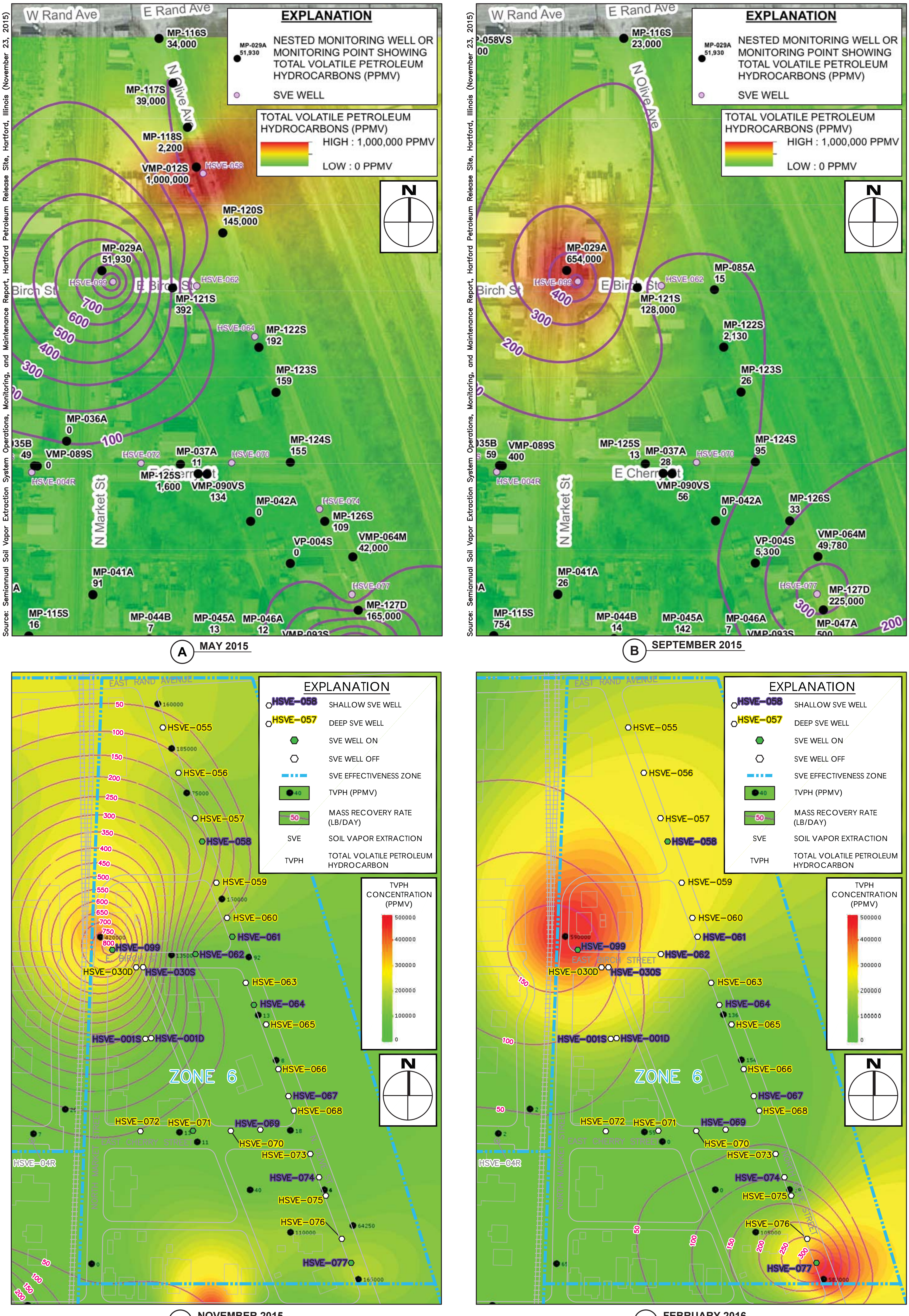
FILE: 00107_15-17_BenzeneAnalyses_201606.dwg



TITLE: FIGURE 17. DISSOLVED PHASE BENZENE CONCENTRATION TREND FOR MONITORING WELL MP-085C - EPA STRATUM	NO SCALE SCALE.	16-001-07 PROJECT NO.	06/21/16 DATE.	TWOONETWO ENVIRONMENTAL 816 Delta Avenue Cincinnati, Ohio 45226 (513) 430-1766
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS	JGP DRAWN.	PEM CHECKED.	REV. 0 REVISION.	

FILE: 00107_20_FIDMassRecovery_201606.dwg

Source: Semiannual Soil Vapor Extraction System Operations, Monitoring, and Maintenance Report, Hartford Petroleum Release Site, Hartford, Illinois (November 23, 2015)



TITLE: FIGURE 18. DISTRIBUTION OF TOTAL VOLATILE PETROLEUM HYDROCARBONS AND MASS RECOVERY RATE	1" = 160' SCALE.	16-001-07 PROJECT NO.	06/16/16 DATE.
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS	JGP DRAWN.	SLT CHECKED.	REV. 0 REVISION.

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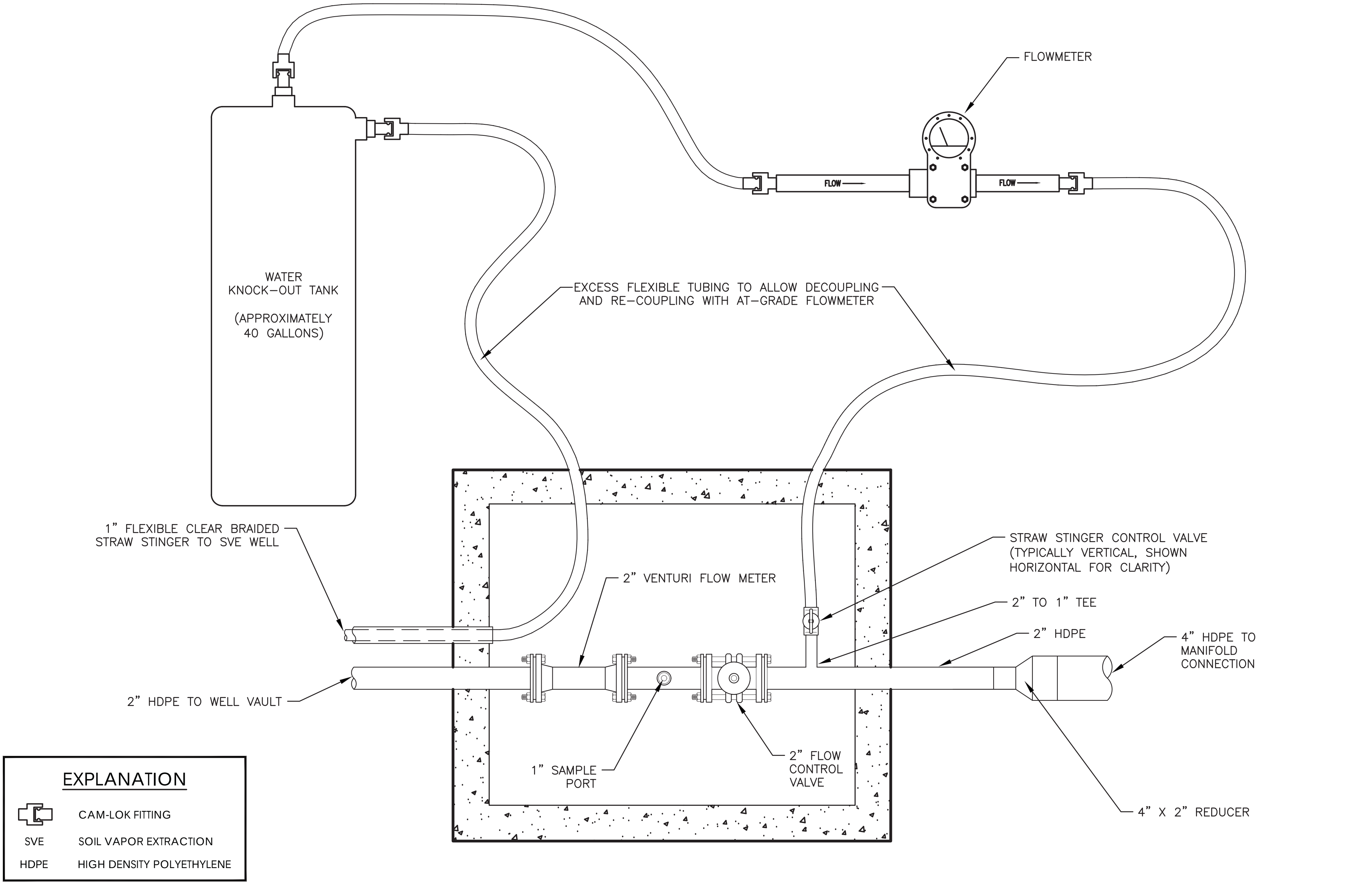
FILE: 00107_18_TPE_Setup_201606.dwg



EXPLANATION

(symbol)	CAM-LOK FITTING
SVE	SOIL VAPOR EXTRACTION
HDPE	HIGH DENSITY POLYETHYLENE

TITLE: FIGURE 19. VAPOR AND WATER FLOW RATE MEASUREMENT EQUIPMENT DETAILS

SITE: HARTFORD PETROLEUM RELEASE SITE
HARTFORD, ILLINOIS

SCALE.	PROJECT NO.	DATE.
NO SCALE	16-001-07	06/20/16

DRAWN.	CHECKED.	REVISION.
JGP	SLT	REV. 0

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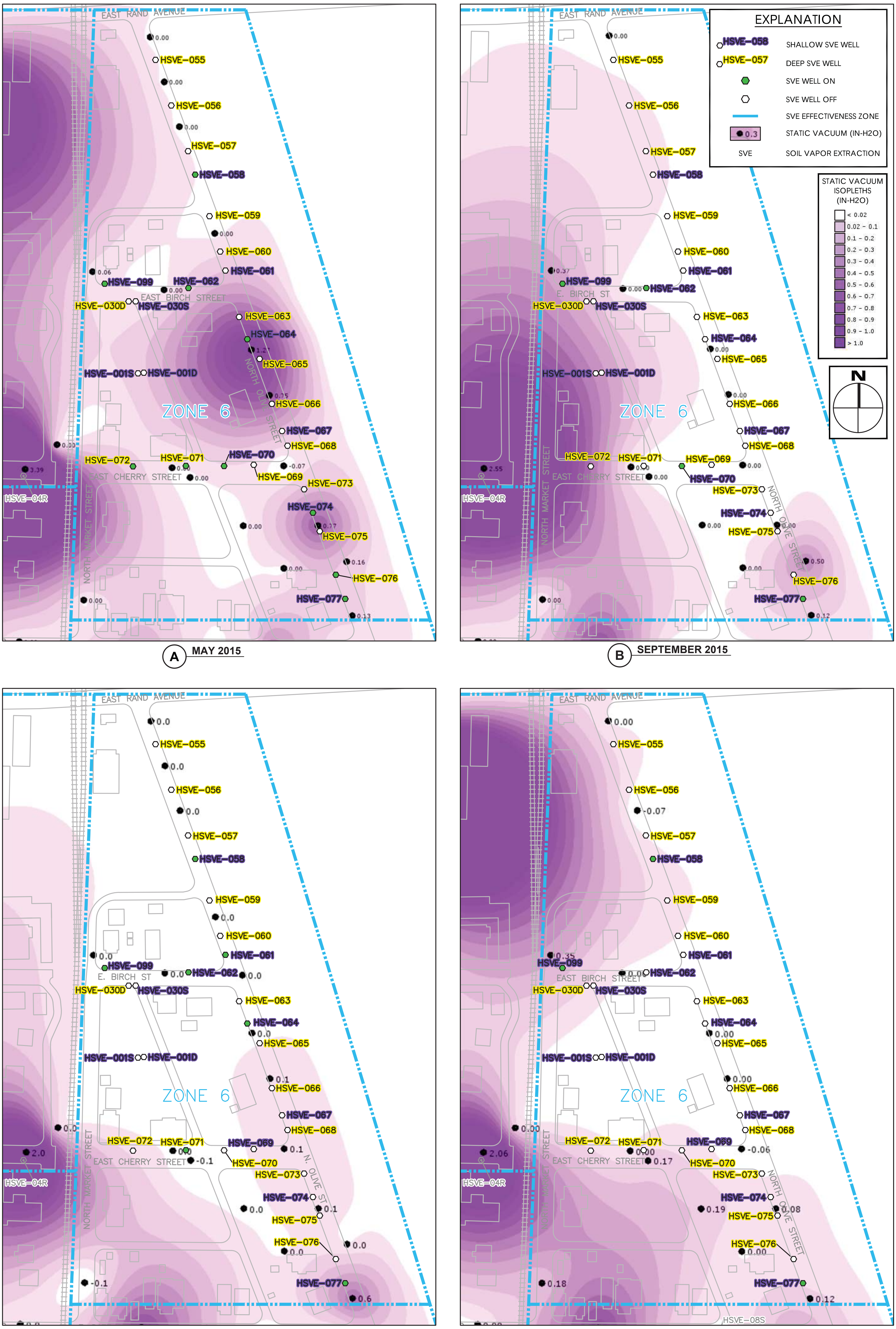
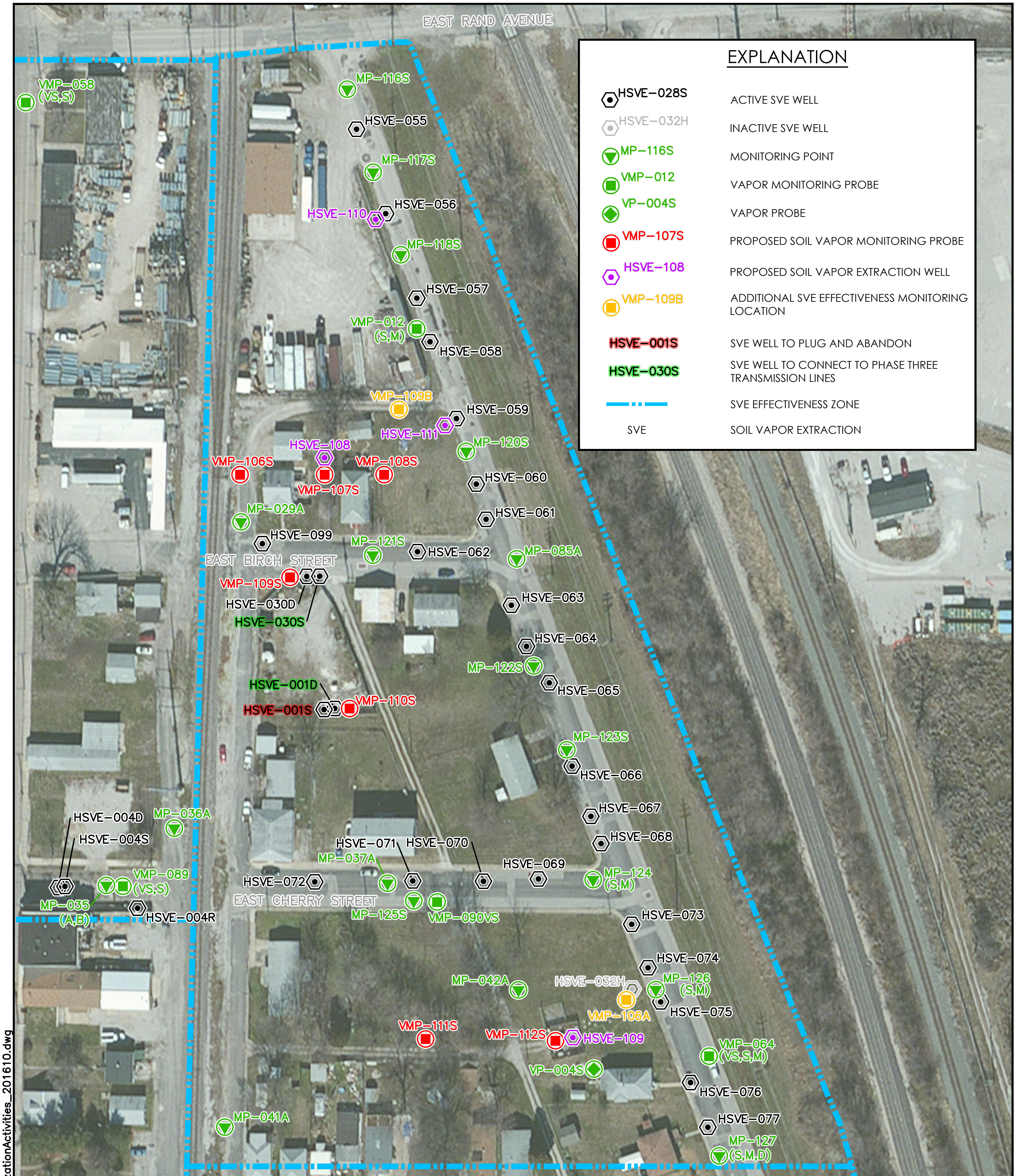
FILE: 00107_19_VacNOlive_201606.dwg



TITLE: FIGURE 20. STATIC VACUUM ISOPLETHS WITHIN THE NORTH OLIVE STRATUM	1" = 180' SCALE.	16-001-07 PROJECT NO.	06/20/16 DATE.	TWOONETWO ENVIRONMENTAL 816 Delta Avenue Cincinnati, Ohio 45226 (513) 430-1766
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS	JGP DRAWN.	SLT CHECKED.	REV. 0 REVISION.	



FILE: 00107_21_OptimizationActivities_201610.dwg

TITLE: FIGURE 21. SUMMARY OF PROPOSED SYSTEM OPTIMIZATION ACTIVITIES	1" = 120' SCALE.	16-001-07 PROJECT NO.	10/26/16 DATE.
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS	JGP DRAWN.	SLT CHECKED.	REV. 0 REVISION.

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APPENDIX A

Note: Appendix A-2 is a Leapfrog Viewer file and cannot be attached to the pdf version of the report

APPENDIX A-1

DETAILED LITHOLOGIC 3-DIMENSIONAL VISUALIZATION ANALYSIS SUMMARY

This appendix provides a summary of the model inputs and assumptions used to develop the three dimensional (3D) visualization of the detailed lithology underlying Soil Vapor Extraction (SVE) System Effectiveness Zone 6 (Zone 6) of the Hartford Petroleum Release Site (Hartford Site). A viewer file of the detailed lithologic and generalized stratigraphic 3D visualizations is provided as Appendix A-2.

Lithologic data (i.e., data specifying the start and end depth of a particular soil type) from 48 unique borings were used to develop the detailed 3D visualization. The lithology described by the geologist was assigned a United Soil Classification System (USCS) soil type, which was recorded on the log generated for each soil boring. The USCS soil types were converted to a numerical value based on grain size and sorting as follows:

Soil Description	USCS Soil Type	Numeric Value
High plasticity clays, fat clays	CH	1
Low to medium plasticity clays, lean clays	CL	2
Low to medium plasticity clays with low plasticity silts	CL/ML	3
High plasticity silts with high plasticity clays	MH/CH	4
Low plasticity silts with high plasticity clays	ML/CH	5
Low plasticity silts with low to medium plasticity clays	ML/CL	6
Low plasticity silts	ML	7
Low plasticity silts with silty sands	ML/SM	8
Silty sands with low plasticity silts	SM/ML	9
Clayey sands, sand-clay mixtures	SC	10
Clayey sands with silty sands	SC/SM	11
Silty sands with clayey sands	SM/SC	12
Silty sands, sand-silt mixtures	SM	13
Silty sands with poorly graded sands or gravelly sands	SM/SP	14
Poorly graded sands or gravelly sands	SP	15
Well graded sands or gravelly sands	SW	16

The numerical values assigned for each vertical lithologic interval were then incorporated into Leapfrog Hydro 4.0™ (Leapfrog) for interpolation via the implicit modelling software. Leapfrog uses a proprietary interpolation tool (FastRBF™) that has been developed to dramatically speed up the process of creating 3D visualizations of subsurface geology and other environmental data (e.g., soil vapor analytical data, groundwater elevation, etc.). This allows the model to be updated quickly and for numerous interpretations to be visualized. In this fashion, the uncertainty related with specific assumptions and inputs can be considered.

For the purpose of this discussion, the cross section showing the detailed lithologic interpretation along North Olive Avenue in Zone 6 (presented on Figure 1 below) will be used for reference. Adjustments to the described inputs will be shown for comparison to the reference cross section to demonstrate their impact, or lack thereof, on the 3D visualization of the detailed lithologic interpretation.

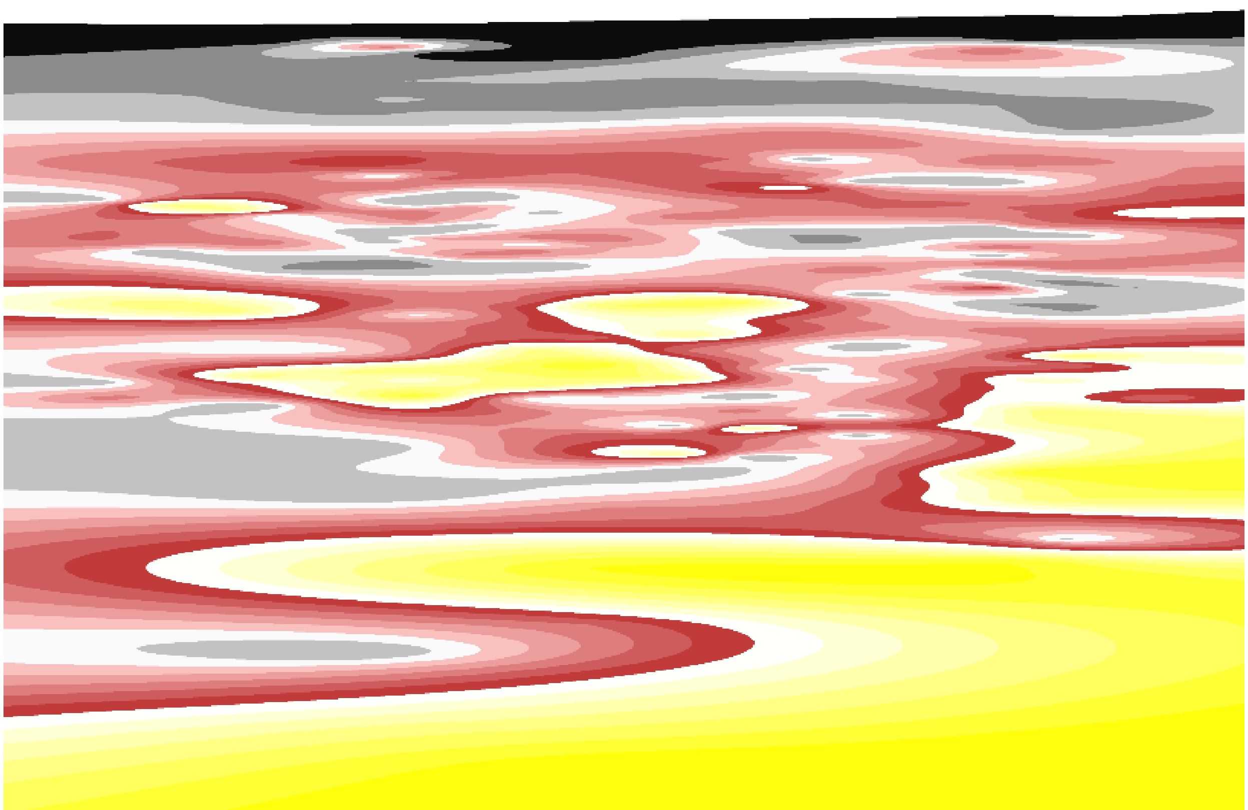

Figure 1. Baseline detailed lithologic cross section along North Olive Avenue (10X vertical exaggeration)

COMPOSITING

In order to perform a numeric interpolation with interval data, Leapfrog provides a tool (referred to as Composting) that is able to convert interval data into numeric point data. The user is able to define parameters such as the Compositing Length and Minimum Coverage, which dictate how the resulting point file is created prior to interpolation. The initial detailed lithologic 3D visualization made use of composting with the following inputs shown on Figure 2:

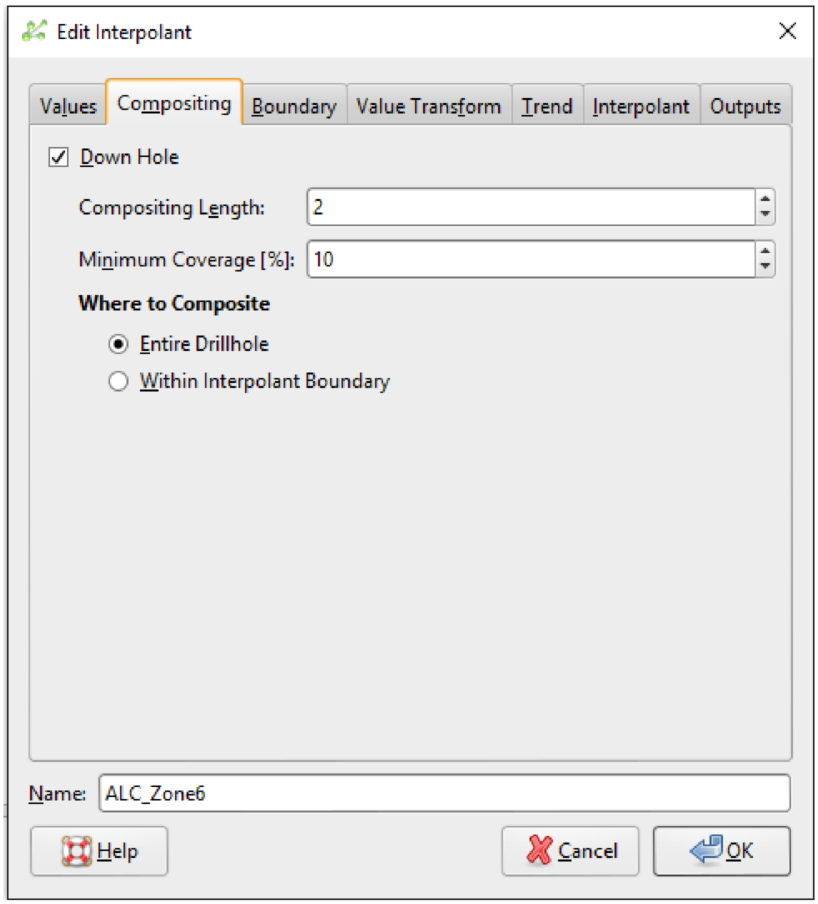

Figure 2. Compositing inputs selected for initial 3D visualization of the detailed lithologic interpretation

A Compositing Length of 2 feet indicates that a point value is assigned for every 2 feet of the boring. A Minimum Coverage of 10% indicates that at least 10% of the Compositing Length must be present for a point value to be assigned. Thus, in the above example, an interval of less than 0.2 feet (i.e., 10% of 2 feet) would not be represented in the resulting interpolation. A visualization using the above compositing options is presented on Figure 3.

Figure 3. Detailed lithologic cross section along North Olive Avenue using compositing tool with 2-foot Compositing Length and 10% Minimum Coverage (10X vertical exaggeration)

As the purpose of the additional 3D visualization was to create a detailed lithologic interpretation for Zone 6, ignoring even small intervals within lithologic log generated by the geologist was deemed undesirable and therefore compositing was not used in generating the final visualization within Leapfrog.

VALUE TRANSFORM

Leapfrog allows for logarithmic transforming of numeric data. This is typically used if the data range spans orders of magnitude. As the numeric lithological data only ranged from 0 to 16, no value transformations were performed.

TREND

The Trend input provides control over the continuity of grade in the resulting interpolant. For the detailed lithologic visualization, a constant trend was applied to the numeric interpolant as vertical anisotropy is known to be present among lithologic sequences. The trend inputs used for the detailed lithologic visualization are presented on Figure 4.

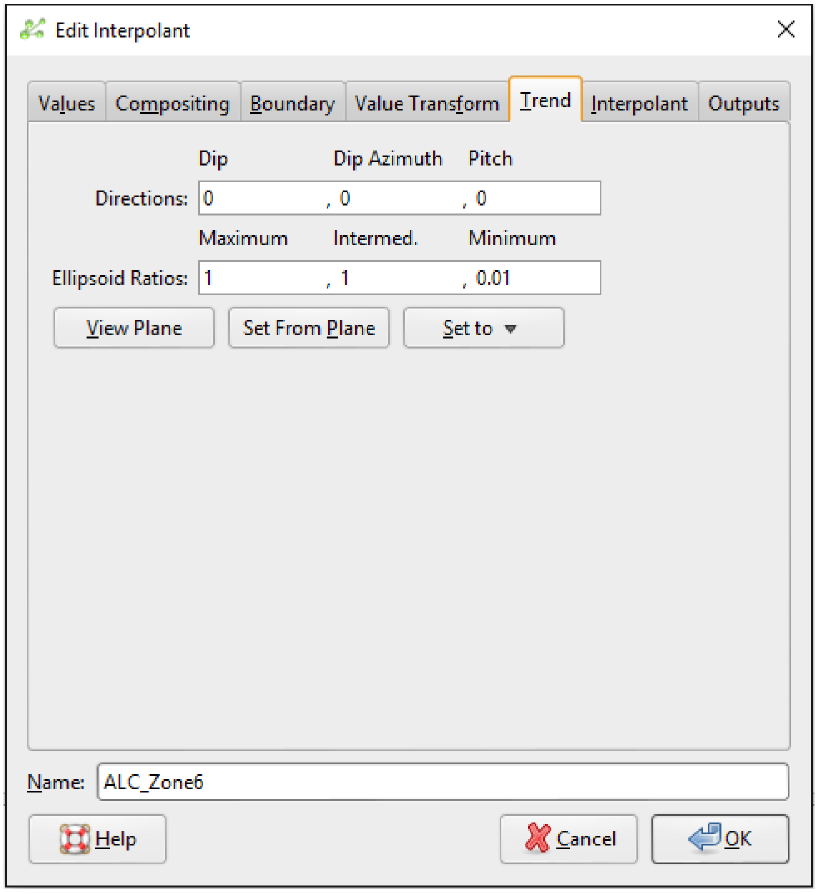

Figure 4. Trend inputs used for the detailed 3D lithologic visualization

According to Leapfrog (Spragg 2013a), this constant trend will favor grade continuity in one direction, “Maximum”, over two others, “Intermed” (intermediate) and “Minimum”. The extent to which one direction is favored over the others is defined by the relative sizes of the “Ellipsoid Ratios”. The direction with the largest ratio is favored more than the others, while the direction with the smallest is favored least (Spragg 2013a). For the detailed lithologic model, the Minimum Ellipsoid Ratio was set to 0.01, which is equivalent to a 100:1 horizontal to vertical anisotropy (H:V). Reference literature indicating the most appropriate degree of anisotropy is not available, and according to Leapfrog (Tam 2016), this parameter is most often defined based on inspection of the resulting visualization, such that the interpretation appears representative of typical geological sections developed for a project site. Figures 5 and 6 present cross sections through North Olive Avenue in Zone 6 using a 20:1 H:V anisotropy and 10:1 H:V anisotropy, respectively.

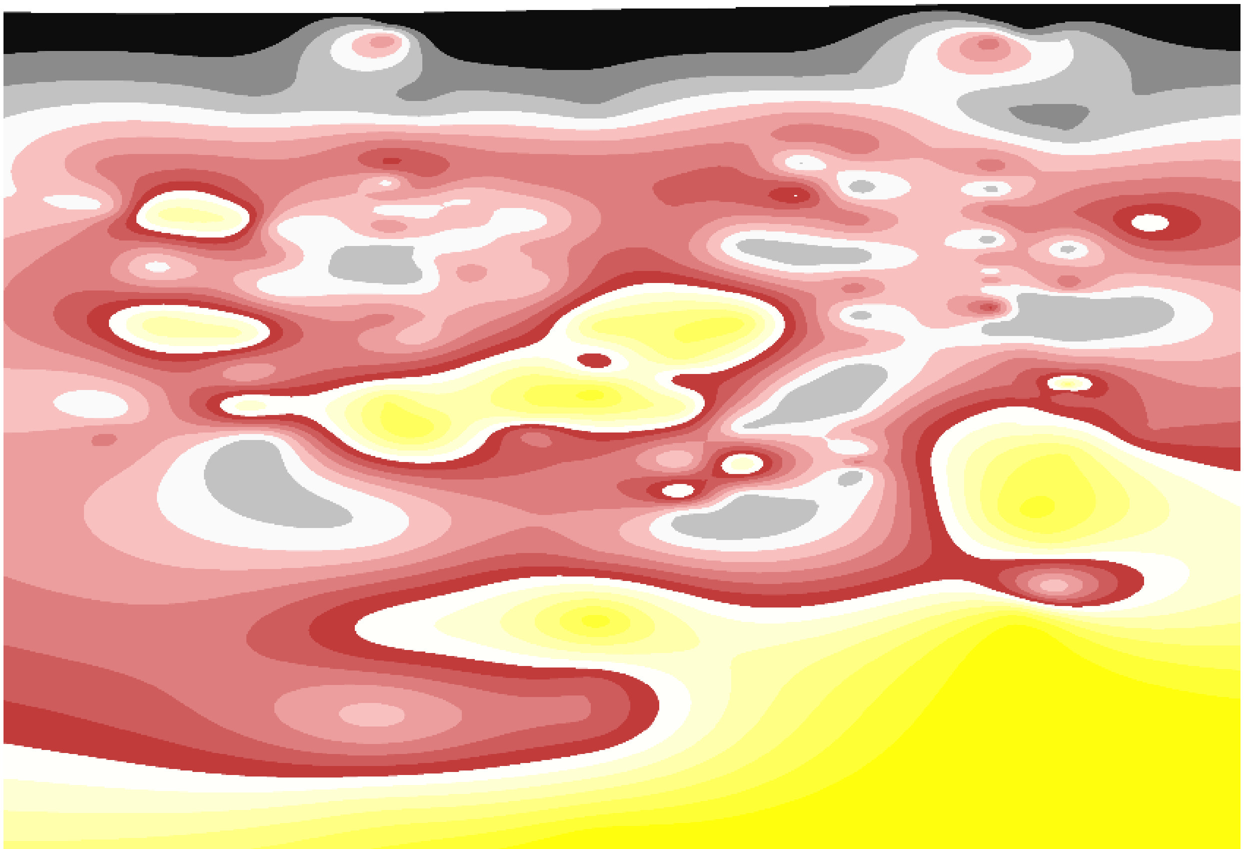

Figure 5. Detailed lithologic cross section along North Olive Avenue with 20H:1V assumed vertical anisotropy (10X vertical exaggeration)

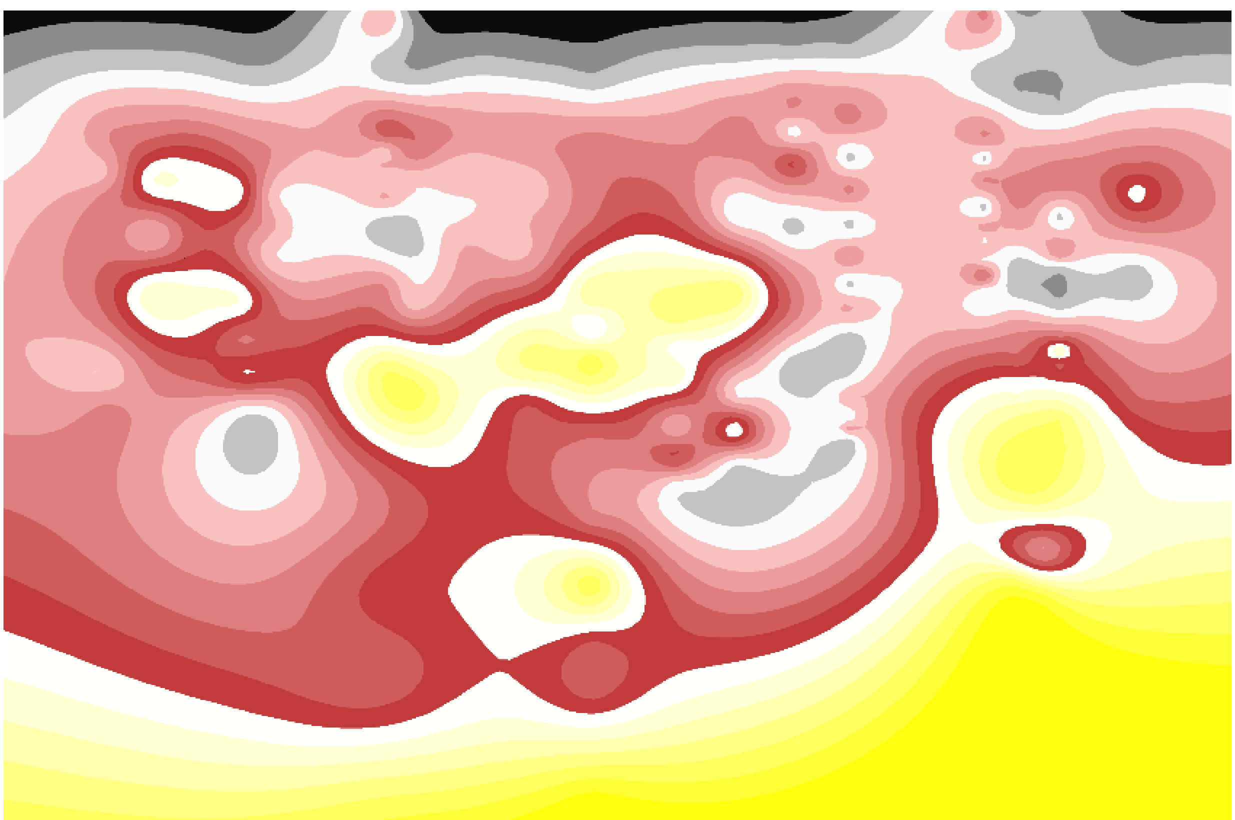

Figure 6. Detailed lithologic cross section along North Olive Avenue with 10H:1V assumed vertical anisotropy (10X vertical exaggeration)

INTERPOLANT

By default, a linear interpolation (i.e., not spheroidal) was applied to the numerical lithologic data. According to Leapfrog (Spragg 2013b), the linear interpolant will strongly reflect values at nearby points and is useful for sparsely or irregularly sampled data. Linear interpolation works well for lithology data, but is not appropriate for values with a distinct finite range of influence (McLennan 2013). A linear interpolation assumes that known values closer to the point being estimated have a proportionally greater influence than points that are farther away. Figure 7 presents the default inputs used for the interpolant settings.

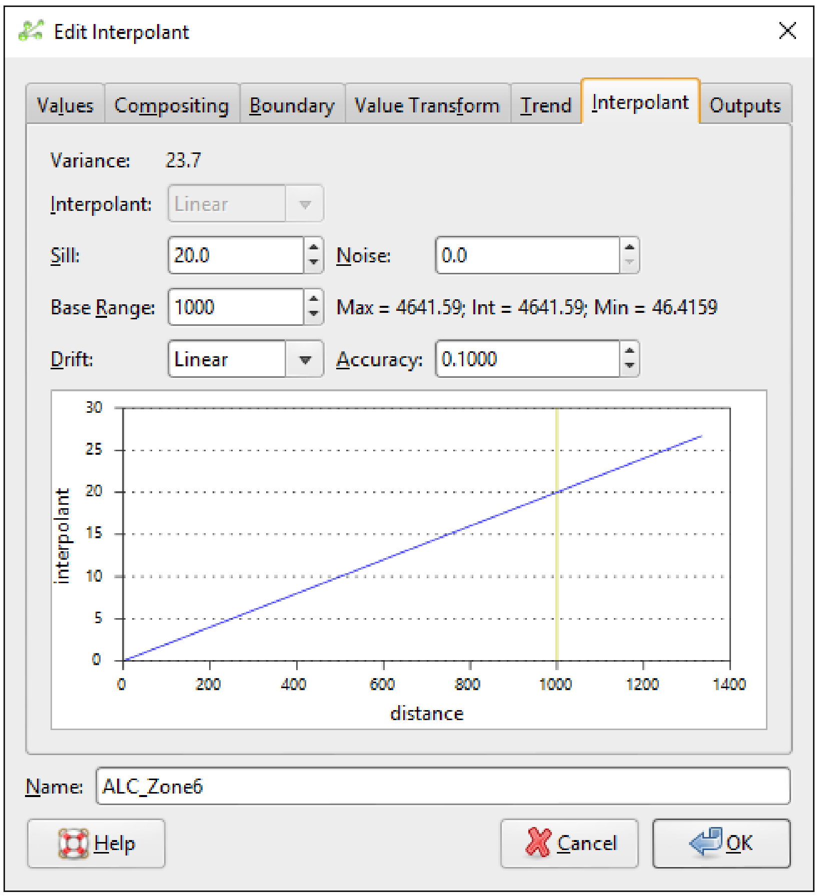

Figure 7. Interpolant inputs used for detailed lithologic 3D visualization

A linear interpolant has no sill or range in the traditional sense, and according to Leapfrog (Tam 2016), these terms are "carryovers" from Leapfrog Geo and other common geologic modelling software packages. In this context, the Sill and Base Range basically set the slope of the interpolant (blue line), with the Base Range defined as distance at which the interpolant value is the Sill. The default values of 20 and 1000 were used for the Sill and Base Range, respectively.

Noise is a measure of the degree of local anomaly in the data. Increasing the value of Noise places more emphasis on the average value of surrounding samples and less on the actual data point. If sample results have a high degree of inaccuracy, a higher setting is recommended (Leapfrog 2016). The default value of 0 was applied for the 3D visualization of the detailed lithology.

Drift describes the value distribution far away from the measured data. It determines the behavior of the visualization for locations that are a long way from sampled data. When set to Constant, the interpolant will go to the approximated "declustered mean" of the data. When set to Linear, the interpolant will behave linearly away from data (Leapfrog 2016). The default setting, linear drift, was assumed.

Finally, Leapfrog estimates the Accuracy from the data values by taking a fraction of the smallest difference between measured data values. The default value of 0.1 was applied.

OUTPUTS

A set of 16 iso-surfaces, set to enclose each interval were defined under the Outputs setting. The selected iso-surface values and associated color assignments are indicated on Figure 8 below:

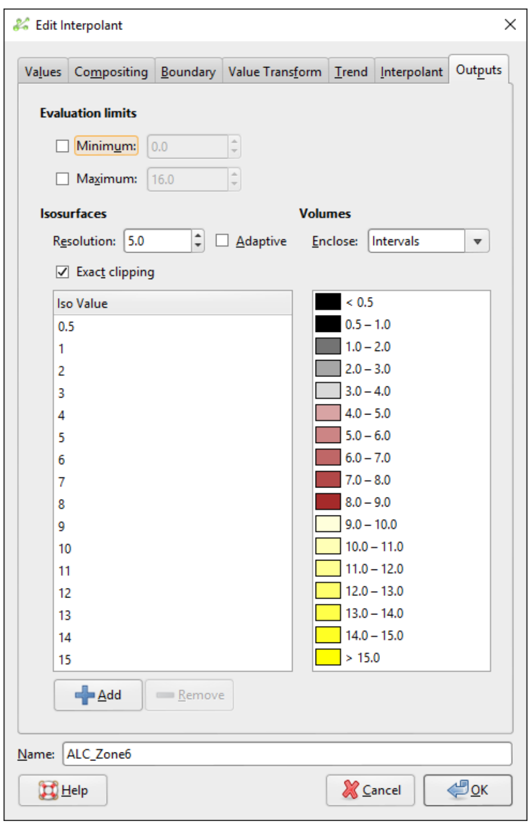

Figure 8. Output options used for detailed lithologic 3D visualization

In Leapfrog, meshes are used to represent surfaces in the form of vertices and triangles that define the 3D shape of the surface. The resolution of a surface is controlled by the size of the triangles used to create a surface. A lower surface resolution value means smaller triangles and, therefore, a finer resolution. A conservatively low value of 5 feet resolution was applied to the 3D visualization of the detailed lithology.

VERTICAL EXAGGERATION

In order for lithologic strata to be visible, a vertical exaggeration of 10 times was applied to all sections cut through the 3D visualization. It is clear that some vertical exaggeration is necessary to observe discrete lithologic layers; however, the value of 10 times was arbitrarily chosen. For comparison, a value of 5 times and no vertical exaggeration for the reference cross section are presented below as Figure 9 and Figure 10, respectively.

Figure 9. Detailed lithologic cross section along North Olive Avenue shown at 5x vertical exaggeration

Figure 10. Detailed lithologic cross section along North Olive Avenue shown with no (1X) vertical exaggeration

With no vertical exaggeration (Figure 10), the individual lithologic layers are nearly indiscernible and the highly interbedded nature of the glaciofluvial sediments becomes apparent. At 5 times vertical exaggeration (Figure 9), distinguishing lithologic layers is possible, but difficult. At 10 times vertical exaggeration (Figure 1), the lithologic sequences are easily discernable. Note that, while necessary for visualization purposes, the reader should be cognizant of this distortion in the cross sections introduced through vertical exaggeration.

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Leapfrog. 2016. "The Linear Interpolant Function". Leapfrog Help Files (http://help.leapfrog3d.com/). Viewed June 23, 2016.

McLennan, Tim (Leapfrog). 2013. "Interpolant Function in Leapfrog Geo". Leapfrog Blog Post July 26, 2013. Viewed June 23, 2016.

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Spragg, Kirk. 2013b. "Leapfrog Interpolation Basics". Leapfrog Blog Post May 8, 2013. Viewed June 23, 2016.

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APPENDIX B

APPENDIX B. SOIL VAPOR EXTRACTION SYSTEM TRIGGER GROUNDWATER ELEVATION SUMMARY

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Date	Measuring Point Elevation (ft-amsl)	Depth to Product (ft-bgs)	Depth to Water (ft-bgs)	Product Thickness (ft)	Groundwater Elevation (ft-amsl)	Corrected Groundwater Elevation (ft-amsl)	Trigger Elevation (ft-amsl)	Below Trigger (Y/N)
HMW-044B	6/17/2016	429.41	22.98	23.16	0.18	406.25	406.39	406.50	Y
	6/6/2016	429.41	--	22.94	--	406.47	406.47	406.50	Y
	6/2/2016	429.41	--	22.94	--	406.47	406.47	406.50	Y
	5/19/2016	429.41	--	22.97	--	406.44	406.44	406.50	Y
	5/11/2016	429.41	--	23.20	--	406.21	406.21	406.50	Y
	5/5/2016	429.41	--	23.17	--	406.24	406.24	406.50	Y
	4/25/2016	429.41	--	23.27	--	406.14	406.14	406.50	Y
	4/14/2016	429.41	23.25	23.42	0.17	405.99	406.12	406.50	Y
	4/5/2016	429.41	--	23.23	--	406.18	406.18	406.50	Y
	3/29/2016	429.41	23.22	23.40	0.18	406.01	406.15	406.50	Y
	3/24/2016	429.41	23.20	23.42	0.22	405.99	406.16	406.50	Y
	3/15/2016	429.41	23.19	23.43	0.24	405.98	406.16	406.50	Y
	3/10/2016	429.41	23.15	23.33	0.18	406.08	406.22	406.50	Y
	3/3/2016	429.41	23.14	23.37	0.23	406.04	406.22	406.50	Y
	2/25/2016	429.41	--	23.07	--	406.34	406.34	406.50	Y
	2/19/2016	429.41	--	23.00	--	406.41	406.41	406.50	Y
	2/9/2016	429.41	--	22.38	--	407.03	407.03	406.50	N
	2/1/2016	429.41	--	21.70	--	407.71	407.71	406.50	N
	1/26/2016	429.41	--	21.08	--	408.33	408.33	406.50	N
	1/19/2016	429.41	--	20.37	--	409.04	409.04	406.50	N
	1/5/2016	429.41	--	19.72	--	409.69	409.69	406.50	N
	12/31/2015	429.41	21.22	21.32	0.10	408.09	408.17	406.50	N
	12/28/2015	429.41	--	23.35	--	406.06	406.06	406.50	Y
	12/21/2015	429.41	--	--	--	--		406.50	--
	12/18/2015	429.41	--	--	--	--		406.50	--
	12/16/2015	429.41	--	23.33	--	406.08	406.08	406.50	Y
	12/2/2015	429.41	23.32	23.45	0.13	405.96	406.06	406.50	Y
HMW-044B	11/23/2015	429.41	23.28	23.29	0.01	406.12	406.13	406.50	Y
	11/18/2015	429.41	--	23.28	--	406.13	406.13	406.50	Y
	10/27/2015	429.41	23.24	23.41	0.17	406.00	406.13	406.50	Y
	10/14/2015	429.41	23.20	23.41	0.21	406.00	406.16	406.50	Y

Location	Date	Measuring Point Elevation	Depth to Product	Depth to Water	Product Thickness	Groundwater Elevation	Corrected Groundwater Elevation	Trigger Elevation	Below Trigger
		(ft-amsl)	(ft-bgs)	(ft-bgs)	(ft)	(ft-amsl)	(ft-amsl)	(ft-amsl)	(Y/N)
	9/30/2015	429.41	23.15	23.42	0.27	405.99	406.20	406.50	Y
	9/22/2015	429.41	--	23.10	--	406.31	406.31	406.50	Y
	9/15/2015	429.41	23.06	23.41	0.35	406.00	406.27	406.50	Y
	9/8/2015	429.41	23.00	23.35	0.35	406.06	406.33	406.50	Y
MP-029C	6/17/2016	429.39	--	18.00	--	411.39	411.39	408.00	N
	6/6/2016	429.39	--	16.95	--	412.44	412.44	408.00	N
	6/2/2016	429.39	--	16.90	--	412.49	412.49	408.00	N
	5/19/2016	429.39	--	16.67	--	412.72	412.72	408.00	N
	5/11/2016	429.39	--	17.85	--	411.54	411.54	408.00	N
	5/5/2016	429.39	--	18.42	--	410.97	410.97	408.00	N
	4/25/2016	429.39	--	19.33	--	410.06	410.06	408.00	N
	4/14/2016	429.39	--	20.02	--	409.37	409.37	408.00	N
	4/5/2016	429.39	--	20.95	--	408.44	408.44	408.00	N
	3/29/2016	429.39	--	20.95	--	408.44	408.44	408.00	N
	3/24/2016	429.39	--	20.30	--	409.09	409.09	408.00	N
	3/15/2016	429.39	--	20.45	--	408.94	408.94	408.00	N
	3/10/2016	429.39	--	20.42	--	408.97	408.97	408.00	N
	3/3/2016	429.39	--	19.56	--	409.83	409.83	408.00	N
	2/25/2016	429.39	--	19.72	--	409.67	409.67	408.00	N
	2/19/2016	429.39	--	18.70	--	410.69	410.69	408.00	N
	2/9/2016	429.39	--	17.52	--	411.87	411.87	408.00	N
	2/1/2016	429.39	--	16.76	--	412.63	412.63	408.00	N
MP-029C	1/26/2016	429.39	--	15.71	--	413.68	413.68	408.00	N
	1/19/2016	429.39	--	14.68	--	414.71	414.71	408.00	N
	1/5/2016	429.39	--	14.08	--	415.31	415.31	408.00	N
	12/31/2015	429.39	--	16.81	--	412.58	412.58	408.00	N
	12/28/2015	429.39	--	18.35	--	411.04	411.04	408.00	N
	12/21/2015	429.39	--	19.59	--	409.80	409.80	408.00	N
	12/18/2015	429.39	--	20.29	--	409.10	409.10	408.00	N
	12/16/2015	429.39	--	20.29	--	409.10	409.10	408.00	N

Location	Date	Measuring Point Elevation	Depth to Product	Depth to Water	Product Thickness	Groundwater Elevation	Corrected Groundwater Elevation	Trigger Elevation	Below Trigger
		(ft-amsl)	(ft-bgs)	(ft-bgs)	(ft)	(ft-amsl)	(ft-amsl)	(ft-amsl)	(Y/N)
	12/2/2015	429.39	--	21.45	--	407.94	407.94	408.00	Y
	11/23/2015	429.39	--	22.58	--	406.81	406.81	408.00	Y
	11/18/2015	429.39	--	21.03	--	408.36	408.36	408.00	N
	10/27/2015	429.39	--	22.78	--	406.61	406.61	408.00	Y
	10/13/2015	429.39	--	22.04	--	407.35	407.35	408.00	Y
	10/2/2015	429.39	--	21.16	--	408.23	408.23	408.00	N
	9/22/2015	429.39	--	20.87	--	408.52	408.52	408.00	N
	9/15/2015	429.39	--	20.30	--	409.09	409.99	408.00	N
	9/8/2015	429.39	--	19.40	--	409.99	409.99	408.00	N
MP-039B	6/17/2016	432.10	--	18.18	--	413.92	413.92	409.00	N
	6/6/2016	432.10	--	17.25	--	414.85	414.85	409.00	N
	6/2/2016	432.10	--	17.99	--	414.11	414.11	409.00	N
	5/19/2016	432.10	--	16.43	--	415.67	415.67	409.00	N
	5/11/2016	432.10	--	17.00	--	415.10	415.10	409.00	N
	5/5/2016	432.10	--	17.25	--	414.85	414.85	409.00	N
	4/25/2016	432.10	--	18.73	--	413.37	413.37	409.00	N
	4/14/2016	432.10	--	19.13	--	412.97	412.97	409.00	N
	4/5/2016	432.10	--	20.20	--	411.90	411.90	409.00	N
MP-039B	3/29/2016	432.10	--	20.38	--	411.72	411.72	409.00	N
	3/24/2016	432.10	--	20.12	--	411.98	411.98	409.00	N
	3/15/2016	432.10	--	20.00	--	412.10	412.10	409.00	N
	3/10/2016	432.10	--	19.85	--	412.25	412.25	409.00	N
	3/3/2016	432.10	--	19.13	--	412.97	412.97	409.00	N
	2/25/2016	432.10	--	18.70	--	413.40	413.40	409.00	N
	2/19/2016	432.10	--	18.00	--	414.10	414.10	409.00	N
	2/9/2016	432.10	--	17.00	--	415.10	415.10	409.00	N
	2/1/2016	432.10	--	16.18	--	415.92	415.92	409.00	N
	1/26/2016	432.10	--	15.38	--	416.72	416.72	409.00	N
	1/19/2016	432.10	--	14.33	--	417.77	417.77	409.00	N
	1/5/2016	432.10	--	12.85	--	419.25	419.25	409.00	N

Location	Date	Measuring Point Elevation	Depth to Product	Depth to Water	Product Thickness	Groundwater Elevation	Corrected Groundwater Elevation	Trigger Elevation	Below Trigger
		(ft-amsl)	(ft-bgs)	(ft-bgs)	(ft)	(ft-amsl)	(ft-amsl)	(ft-amsl)	(Y/N)
	12/31/2015	432.10	--	13.02	--	419.08	419.08	409.00	N
	12/28/2015	432.10	--	16.00	--	416.10	416.10	409.00	N
	12/21/2015	432.10	--	20.92	--	411.18	411.18	409.00	N
	12/18/2015	432.10	--	21.33	--	410.77	410.77	409.00	N
	12/16/2015	432.10	--	21.32	--	410.78	410.78	409.00	N
	12/2/2015	432.10	--	21.67	--	410.43	410.43	409.00	N
	11/23/2015	432.10	--	22.32	--	409.78	409.78	409.00	N
	11/18/2015	432.10	--	23.43	--	408.67	408.67	409.00	Y
	10/27/2015	432.10	--	23.62	--	408.48	408.48	409.00	Y
	10/13/2015	432.10	--	22.91	--	409.19	409.19	409.00	N
	9/29/2015	432.10	--	22.16	---	409.94	409.94	409.00	N
	9/22/2015	432.10	--	21.76	--	410.34	410.34	409.00	N
	9/15/2015	432.10	--	21.19	--	410.91	411.65	409.00	N
	9/8/2015	432.10	--	20.45	--	411.65	411.65	409.00	N
MP-053B	6/17/2016	430.60	23.97	24.37	0.40	406.23	406.54	406.50	N
	6/6/2016	430.60	23.94	24.34	0.40	406.26	406.57	406.50	N
	6/2/2016	430.60	23.95	24.35	0.40	406.25	406.56	406.50	N
	5/19/2016	430.60	--	23.97	--	406.63	406.63	406.50	N
	5/11/2016	430.60	23.98	24.38	0.40	406.22	406.53	406.50	N
	5/5/2016	430.60	--	24.00	--	406.60	406.60	406.50	N
	4/25/2016	430.60	--	24.10	--	406.50	406.50	406.50	Y
	4/14/2016	430.60	24.10	24.16	0.06	406.44	406.49	406.50	Y
	4/5/2016	430.60	24.10	24.47	0.37	406.13	406.41	406.50	Y
	3/29/2016	430.60	24.10	24.47	0.37	406.13	406.41	406.50	Y
	3/24/2016	430.60	24.10	24.47	0.37	406.13	406.41	406.50	Y
	3/15/2016	430.60	24.11	24.49	0.38	406.11	406.40	406.50	Y
	3/10/2016	430.60	24.10	24.38	0.28	406.22	406.44	406.50	Y
	3/3/2016	430.60	24.12	24.50	0.38	406.10	406.39	406.50	Y
	2/25/2016	430.60	24.11	24.12	0.01	406.48	406.49	406.50	Y
	2/19/2016	430.60	24.12	24.50	0.38	406.10	406.39	406.50	Y

Location	Date	Measuring Point Elevation (ft-amsl)	Depth to Product (ft-bgs)	Depth to Water (ft-bgs)	Product Thickness (ft)	Groundwater Elevation (ft-amsl)	Corrected Groundwater Elevation (ft-amsl)	Trigger Elevation (ft-amsl)	Below Trigger (Y/N)
	2/9/2016	430.60	24.04	24.52	0.48	406.08	406.45	406.50	Y
	2/1/2016	430.60	--	23.63	--	406.97	406.97	406.50	N
	1/26/2016	430.60	--	23.39	--	407.21	407.21	406.50	N
	1/19/2016	430.60	22.62	23.10	0.48	407.50	407.87	406.50	N
	1/5/2016	430.60	20.78	20.96	0.18	409.64	409.78	406.50	N
	12/31/2015	430.60	21.43	21.62	0.19	408.98	409.13	406.50	N
	12/28/2015	430.60	23.63	23.66	0.03	406.94	406.96	406.50	Y
	12/21/2015	430.60	--	24.37	--	406.23	406.23	406.50	Y
	12/18/2015	430.60	24.38	24.47	0.09	406.13	406.20	406.50	Y
	12/16/2015	430.60	--	Dry	--	--		406.50	Y
	12/2/2015	430.60	24.38	24.51	0.13	406.09	406.19	406.50	Y
MP-053B	11/23/2015	430.60	24.40	24.48	0.08	406.12	406.18	406.50	Y
	11/18/2015	430.60	24.38	24.48	0.10	406.12	406.20	406.50	Y
	10/27/2015	430.60	24.40	24.48	0.08	406.12	406.18	406.50	Y
	10/13/2015	430.60	--	Dry	--	--		406.50	Y
	10/1/2015	430.60	23.93	24.48	0.55	406.12	406.54	406.50	N
	9/22/2015	430.60	23.93	24.48	0.55	406.12	406.54	406.50	N
	9/15/2015	430.60	23.92	24.48	0.56	406.12	406.55	406.50	N
	9/8/2015	430.60	23.92	24.48	0.56	406.12	406.55	406.50	N
MP-079B	6/17/2016	429.48	--	23.85	--	405.63	405.63	406.00	Y
	6/6/2016	429.48	--	23.32	--	406.16	406.16	406.00	N
	6/2/2016	429.48	--	23.47	--	406.01	406.01	406.00	N
	5/19/2016	429.48	--	23.58	--	405.90	405.90	406.00	Y
	5/11/2016	429.48	--	24.20	--	405.28	405.28	406.00	Y
	5/5/2016	429.48	--	24.35	--	405.13	405.13	406.00	Y
	4/25/2016	429.48	--	24.74	--	404.74	404.74	406.00	Y
	4/14/2016	429.48	--	24.82	--	404.66	404.66	406.00	Y
	4/5/2016	429.48	--	25.10	--	404.38	404.38	406.00	Y
	3/29/2016	429.48	--	25.10	--	404.38	404.38	406.00	Y
	3/24/2016	429.48	--	24.86	--	404.62	404.62	406.00	Y

APPENDIX B. SOIL VAPOR EXTRACTION SYSTEM TRIGGER GROUNDWATER ELEVATION SUMMARY

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Location	Date	Measuring Point Elevation (ft-amsl)	Depth to Product (ft-bgs)	Depth to Water (ft-bgs)	Product Thickness (ft)	Groundwater Elevation (ft-amsl)	Corrected Groundwater Elevation (ft-amsl)	Trigger Elevation (ft-amsl)	Below Trigger (Y/N)
MP-079B	3/15/2016	429.48	--	24.75	--	404.73	404.73	406.00	Y
	3/10/2016	429.48	--	24.82	--	404.66	404.66	406.00	Y
	3/3/2016	429.48	--	24.52	--	404.96	404.96	406.00	Y
	2/25/2016	429.48	--	24.52	--	404.96	404.96	406.00	Y
	2/19/2016	429.48	--	24.00	--	405.48	405.48	406.00	Y
	2/9/2016	429.48	--	23.40	--	406.08	406.08	406.00	N
	2/1/2016	429.48	--	22.75	--	406.73	406.73	406.00	N
	1/26/2016	429.48	--	21.75	--	407.73	407.73	406.00	N
	1/19/2016	429.48	--	20.44	--	409.04	409.04	406.00	N
	1/5/2016	429.48	--	17.74	--	411.74	411.74	406.00	N
	12/31/2015	429.48	--	18.44	--	411.04	411.04	406.00	N
	12/28/2015	429.48	--	21.78	--	407.70	407.70	406.00	N
	12/21/2015	429.48	25.84	25.86	0.02	403.62	403.64	406.00	Y
	12/18/2015	429.48	25.98	26.00	0.02	403.48	403.50	406.00	Y
	12/16/2015	429.48	--	25.94	--	403.54	403.54	406.00	Y
	12/2/2015	429.48	26.10	26.13	0.03	403.35	403.37	406.00	Y
	11/23/2015	429.48	26.18	26.40	0.22	403.08	403.25	406.00	Y
	11/18/2015	429.48	26.15	26.28	0.13	403.20	403.30	406.00	Y
	10/27/2015	429.48	25.72	25.86	0.14	403.62	403.73	406.00	Y
	10/12/2015	429.48	--	25.31	--	404.17	404.17	406.00	Y
	9/29/2015	429.48	24.97	25.15	0.18	404.33	404.47	406.00	Y
	9/22/2015	429.48	24.80	25.01	0.21	404.47	404.63	406.00	Y
	9/15/2015	429.48	24.52	24.71	0.19	404.77	404.92	406.00	Y
	9/8/2015	429.48	24.05	24.22	0.17	405.26	405.39	406.00	Y

Notes:

ft-amsl - feet above mean sea level

ft-btoc - feet below top of casing

ft - feet

-- - not applicable

APPENDIX C

ZONE 6 ENHANCED TPE TEST

Trihydro CORPORATION

Date:	3-1-16	Field Personnel:	CB, RS, WR
Project Name:	Hartford Petroleum Release Site	Recorded by:	CB
Project Number:	245-008-001	Weather:	CLOUDY 36°F
Site Location:	Hartford, Illinois		WINDY

Fluid Level Gauging

Monitoring Well Location	Depth to LNAPL (ft-btoc)	Depth to Groundwater (ft-btoc)	Comments T. D.
HMW-004	—	9.92	26.07
HMW-048B	—	11.21	29.50
MP-085B	—	7.95	20.50

Groundwater Extraction Rate Estimation

HSVE Well Location	Initial Knockout Tank Depth to Water (feet)	Final Knockout Tank Depth to Water (feet)	Time Elapsed (minutes)	Comments
HSVE-057	3.43	1.26	17	LITTLE VACUUM LEAKAGE SO IT
HSVE-059	3.43	2.76	17	CAN KEEP UP
HSVE-060	3.43	3.08	17	

Air Flow Rate

HSVE Well Location	Air Flow Rate (scfm)	Comments
HSVE-057	0	NEEDLE BARELY MOVES
HSVE-059	0	" " "
HSVE-060	0	" " "

ZONE 6 ENHANCED TPE TEST

Trihydro

Date:	3-2-16	Field Personnel:	CB, WR
Project Name:	Hartford Petroleum Release Site	Recorded by:	CB
Project Number:	24S-008-001	Weather:	40°F CLOUDY
Site Location:	Hartford, Illinois		

Fluid Level Gauging

Monitoring Well Location	Depth to LNAPL (ft-btoc)	Depth to Groundwater (ft-btoc)	Comments
HMW-004	—	11.30	
HMW-048B	—	11.04	
MP-085B	—	8.10	

Groundwater Extraction Rate Estimation

HSVE Well Location	Initial Knockout Tank Depth to Water (feet)	Final Knockout Tank Depth to Water (feet)	Time Elapsed (minutes)	Comments
HSVE-057	3.43	3.01	5	
HSVE-059	3.43	3.05	5	
HSVE-060	3.43	3.19	5	

Air Flow Rate

HSVE Well Location	Air Flow Rate (scfm)	Comments
HSVE-057	0	STILL SUCKING WATER. LEFT STINGER IN PLACE.
HSVE-059	0	STILL SUCKING WATER, LEFT STINGER IN PLACE.
HSVE-060	0	STILL SUCKING WATER, LEFT STINGER IN PLACE.

ZONE 6 ENHANCED TPE TEST

Trihydro

Date:	3-3-16	Field Personnel:	CB, RS, WR
Project Name:	Hartford Petroleum Release Site	Recorded by:	CB
Project Number:	245-008-001	Weather:	40°F LIGHT RAIN
Site Location:	Hartford, Illinois		

Fluid Level Gauging

Monitoring Well Location	Depth to LNAPL (ft-btoc)	Depth to Groundwater (ft-btoc)	Comments
HMW-004	—	11.57	
HMW-048B	—	11.42	
MP-085B	—	8.10	

Groundwater Extraction Rate Estimation

HSVE Well Location	Initial Knockout Tank Depth to Water (feet)	Final Knockout Tank Depth to Water (feet)	Time Elapsed (minutes)	Comments
HSVE-057	3.43	3.05	5	
HSVE-059	3.43	3.08	5	
HSVE-060	3.43	3.24	5	

Air Flow Rate

HSVE Well Location	Air Flow Rate (scfm)	Comments
HSVE-057	0	STILL SUCKING WATER. LEFT STINGER IN PLACE.
HSVE-059	0	STILL SUCKING WATER. LEFT STINGER IN PLACE.
HSVE-060	0	STILL SUCKING WATER. LEFT STINGER IN PLACE.

ZONE 6 ENHANCED TPE TEST

Trihydro

Date:	3-4-16	Field Personnel:	WR RS
Project Name:	Hartford Petroleum Release Site	Recorded by:	WR
Project Number:	24S-008-001	Weather:	34° Mostly Cloudy
Site Location:	Hartford, Illinois		

Fluid Level Gauging

Monitoring Well Location	Depth to LNAPL (ft-btoc)	Depth to Groundwater (ft-btoc)	Comments
HMW-004	—	12.01	
HMW-048B	—	11.55	
MP-085B	—	8.25	

Groundwater Extraction Rate Estimation

HSVE Well Location	Initial Knockout Tank Depth to Water (feet)	Final Knockout Tank Depth to Water (feet)	Time Elapsed (minutes)	Comments
HSVE-057	3.43	3.02	5 Min	
HSVE-059	3.43	3.07	5 Min	
HSVE-060	3.43	3.22	5 Min	

Air Flow Rate

HSVE Well Location	Air Flow Rate (scfm)	Comments
HSVE-057	0	Still Sucking water. Left Stinger in Place
HSVE-059	15	Still Sucking water. Left Stinger in Place
HSVE-060	0	Still Sucking water. Left Stinger in place

ZONE 6 ENHANCED TPE TEST

Trihydro

Date:	3-7-16	Field Personnel:	CB, WR
Project Name:	Hartford Petroleum Release Site	Recorded by:	CB
Project Number:	245-008-001	Weather:	60°F CLOUDY
Site Location:	Hartford, Illinois		

Fluid Level Gauging

Monitoring Well Location	Depth to LNAPL (ft-btoc)	Depth to Groundwater (ft-btoc)	Comments
HMW-004	—	12.53	
HMW-048B	—	12.12	
MP-085B	—	8.55	

Groundwater Extraction Rate Estimation

HSVE Well Location	Initial Knockout Tank Depth to Water (feet)	Final Knockout Tank Depth to Water (feet)	Time Elapsed (minutes)	Comments
HSVE-057	3.43	2.99	5	
HSVE-059	3.43	3.10	5	
HSVE-060	3.43	3.22	5	

Air Flow Rate

HSVE Well Location	Air Flow Rate (scfm)	Comments
HSVE-057	0	STILL SUCKING WATER. LEFT STINGER IN PLACE.
HSVE-059	0	STILL SUCKING WATER. LEFT STINGER IN PLACE.
HSVE-060	0	STILL SUCKING WATER. LEFT STINGER IN PLACE.

ZONE 6 ENHANCED TPE TEST

Trihydro

Date:	3-8-16	Field Personnel:	CB, WR
Project Name:	Hartford Petroleum Release Site	Recorded by:	CB
Project Number:	24S-008-001	Weather:	CLOUDY 60°F
Site Location:	Hartford, Illinois		

Fluid Level Gauging

Monitoring Well Location	Depth to LNAPL (ft-btoc)	Depth to Groundwater (ft-btoc)	Comments
HMW-004	—	12.84	
HMW-048B	—	11.80	
MP-085B	—	8.70	

Groundwater Extraction Rate Estimation

HSVE Well Location	Initial Knockout Tank Depth to Water (feet)	Final Knockout Tank Depth to Water (feet)	Time Elapsed (minutes)	Comments
HSVE-057	3.43	3.00	5	
HSVE-059	3.43	2.90	5	
HSVE-060	3.43	3.22	5	

Air Flow Rate

HSVE Well Location	Air Flow Rate (scfm)	Comments
HSVE-057	/	STILL SUCKING WATER. LEFT STINGER IN PLACE
HSVE-059	/	STINGER QUIT DTW = 11.85 DREW WATER DOWN TO 22.26 T.D. = 25.17
HSVE-060	/	STILL SUCKING WATER. LEFT STINGER IN PLACE

ZONE 6 ENHANCED TPE TEST

Trihydro

Date:	3-8-16	Field Personnel:	CB, WR
Project Name:	Hartford Petroleum Release Site	Recorded by:	CB
Project Number:	245-008-001	Weather:	CLOUDY 60°F
Site Location:	Hartford, Illinois		

Fluid Level Gauging

Monitoring Well Location	Depth to LNAPL (ft-btoc)	Depth to Groundwater (ft-btoc)	Comments
HMW-004	—	12.84	
HMW-048B	—	11.80	
MP-085B	—	8.70	

Groundwater Extraction Rate Estimation

HSVE Well Location	Initial Knockout Tank Depth to Water (feet)	Final Knockout Tank Depth to Water (feet)	Time Elapsed (minutes)	Comments
HSVE-057	3.43	3.00	5	
HSVE-059	3.43	2.90	5	
HSVE-060	3.43	3.22	5	

Air Flow Rate

HSVE Well Location	Air Flow Rate (scfm)	Comments
HSVE-057	1.06 - 6.88 4.30	VACUUM = 110
HSVE-059	1.36 - 5.25 2.69	VACUUM = 118
HSVE-060	0.42 - 2.26 1.20	VACUUM = 105

ZONE 6 ENHANCED TPE TEST

Trihydro

Date:	3-9-16	Field Personnel:	CB, WR
Project Name:	Hartford Petroleum Release Site	Recorded by:	CB
Project Number:	24S-008-001	Weather:	CLOUDY 62°F
Site Location:	Hartford, Illinois		

Fluid Level Gauging

Monitoring Well Location	Depth to LNAPL (ft-btoc)	Depth to Groundwater (ft-btoc)	Comments
HMW-004	—	13.00	
HMW-048B	—	11.92	
MP-085B	—	8.82	

Groundwater Extraction Rate Estimation

HSVE Well Location	Initial Knockout Tank Depth to Water (feet)	Final Knockout Tank Depth to Water (feet)	Time Elapsed (minutes)	Comments
HSVE-057	3.43	3.00	5	
HSVE-059	3.43	3.11	5	
HSVE-060	3.43	3.24	5	

Air Flow Rate

HSVE Well Location	Air Flow Rate (scfm)	Comments
HSVE-057	0.95 - 6.21 3.57	VACUUM = 112 STILL SUCKING WATER LEFT STINGER IN PLACE
HSVE-059	1.28 - 3.42 1.78	VACUUM = 114
HSVE-060	0.25 - 1.19 0.69	VACUUM = 114

ZONE 6 ENHANCED TPE TEST

Trihydro

Date:	3-10-16	Field Personnel:	CB, RS
Project Name:	Hartford Petroleum Release Site	Recorded by:	CB
Project Number:	24S-008-001	Weather:	RAIN 49°F
Site Location:	Hartford, Illinois		

Fluid Level Gauging

Monitoring Well Location	Depth to LNAPL (ft-btoc)	Depth to Groundwater (ft-btoc)	Comments
HMW-004	—	13.15	
HMW-048B	—	12.10	
MP-085B	—	8.95	

Groundwater Extraction Rate Estimation

HSVE Well Location	Initial Knockout Tank Depth to Water (feet)	Final Knockout Tank Depth to Water (feet)	Time Elapsed (minutes)	Comments
HSVE-057	3.43	3.00	5	
HSVE-059	3.43	3.09	5	
HSVE-060	3.43	3.21	5	

Air Flow Rate

HSVE Well Location	Air Flow Rate (scfm)	Comments
HSVE-057	1.92 - 4.68 3.54	STILL SUCKING WATER VACUUM = 115 LEFT STINGER IN PLACE
HSVE-059	0.92 - 2.42 1.35	VACUUM = 114
HSVE-060	0.44 - 2.27 1.16	VACUUM = 117

ZONE 6 ENHANCED TPE TEST

Trihydro

Date:	3-11-16	Field Personnel:	CB, RS, WR
Project Name:	Hartford Petroleum Release Site	Recorded by:	CB
Project Number:	24S-008-001	Weather:	45°F CLOUDY
Site Location:	Hartford, Illinois		

Fluid Level Gauging

Monitoring Well Location	Depth to LNAPL (ft-btoc)	Depth to Groundwater (ft-btoc)	Comments
HMW-004	—	13.42	
HMW-048B	—	12.32	
MP-085B	—	9.16	

Groundwater Extraction Rate Estimation

HSVE Well Location	Initial Knockout Tank Depth to Water (feet)	Final Knockout Tank Depth to Water (feet)	Time Elapsed (minutes)	Comments
HSVE-057	3.43	3.09	5	
HSVE-059	3.43	3.17	5	
HSVE-060	3.43	3.27	5	

Air Flow Rate

HSVE Well Location	Air Flow Rate (scfm)	Comments
HSVE-057	0.40 – 5.85 3.60	VACUUM = 118 STILL SUCKING WATER LEFT STINGER IN PLACE
HSVE-059	0.67 – 2.47 1.57	VACUUM = 121
HSVE-060	0.48 – 1.95 0.83	VACUUM = 120